THE

LIFE OF THE PLEISTOCENE OR GLACIAL PERIOD

AS RECORDED IN THE DEPOSITS LAID DOWN BY THE GREAT ICE SHEETS

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PREFACE

About nine years ago, Mr. A. Scharf, a gentleman interested in the study of Archaeology, discovered a bed of mussels, containing the species *Elliptio crassidens*, near the old village of Bowmanville, in the northwestern part of the City of Chicago. These specimens were referred to the writer who doubted their having been found near Chicago, the present distribution of *crassidens* being upwards of a hundred miles from the City, southward and westward. Investigation revealed the presence, hitherto unknown to either the geologists or the zoologists of Chicago, of a fossil deposit of wide extent, which contained not only the species in question but many others, both pelecypods and gastropods. These deposits were in a new drainage canal, called the North Shore Channel, which now extends from Bowmanville northward to Wilmette, a distance of about eight miles.

The writer was fortunate in being able to follow the excavation of this canal foot by foot and thus to secure fresh exposures. During a period of two years the entire length was carefully surveyed with the results described in the pages that follow (Part I). The new Calumet-Sag Channel, draining the southeastern part of the city, was also studied, but in no such detail as was the North Shore Channel. It is greatly to be regretted that this canal, presenting quite as important data as did the North Shore Channel, could not have been given equally as exhaustive study. The small amount of time available was used to the utmost and important data were obtained.

As the work proceeded, it became evident that here was an opportunity to reconstruct the life and conditions of this ancient glacial lake; to ascertain the bearing of this life upon the migration and repopulation of the glaciated area; and to compare the postglacial with the recent fauna and flora. To this end the literature was searched for data relating to this region and much time was spent in different parts of the area in quest of additional material. The study of the Chicago region very naturally led to a consideration of other regions once covered by the great ice sheet and also to other periods of glaciation—the little-known interglacial intervals. The result of these studies is embodied in the two parts of this volume.

Part I embraces an account of the postglacial geology and life of the Chicago region, and also a resumé of our present knowledge concerning the postglacial life of the entire glaciated region of the United States and Canada. In Part II the life of the interglacial intervals is discussed and the species of plants and animals listed. This is largely a compilation, all available literature having been searched for data. In this part the placing of a record in a parti-

cular interval has often been attended with great difficulty on account of the ambiguity concerning its stratigraphic position—its relation to a distinct and well known drift sheet. In some cases only a suggestion has been made, while in many others not even this has been possible. Not a few records, however, have been of such a character as to leave little or no doubt concerning their relation to one of the drift sheets. Only such have been available for reconstructing the life of these intervals. Many of the references are not available because of gross errors of identification, as well as of stratigraphy; such as Aughey's list of Missouri loess mollusks, which is worthless for this reason. In all lists the modern nomenclature is used.

In correlating these records with the particular interglacial interval in which they are supposed to belong the writer has used his judgment, based on the original stratigraphical data or upon some later local geological map or record. It is probable that this judgment has not in all cases been correct. In the list of biotic remains all groups of animals and plants (excepting the Diatomaceae) have been included, in order that a comprehensive view might be presented of the life of each interval. The lists of species at the end of the volume (Chapter XIII) are so meager that they pitifully expose our lack of knowledge and indicate forcefully that much is yet to be done before we are in a position to write intelligently on the life of the Pleistocene.

The title of this volume may be thot to be too inclusive, the region from which the data have been gathered forming but a part of the entire territory in which Pleistocene animals and plants have been found. It was thot, however, that the only way in which a knowledge of the life of the interglacial intervals could be obtained would be to study the life which had been entombed between the till sheets, and which could only have lived during the interval represented. For this reason the area selected for study includes only that part of the United States and Canada (east of the Rocky Mountains) that was covered by the great continental ice sheets. Deposits outside of this area, therefore, cannot be included, except for purposes of comparison, as there is no way of deciding just which interval they may represent. In fact, many of the records beyond the glaciated territory represent deposits which were forming continuously thruout the entire time of the Pleistocene, they not being greatly influenced by the great ice sheets. With this statement of the purpose of the work, it is easily seen that the title "Life of the Pleistocene" is not inappropriate.

Acknowledgments

The writer is greatly indebted to many persons, professional and others, for assistance during the preparation of the work. Chief among these may be mentioned Dr. T. C. Chamberlin and Dr. Rollin Chamberlin, of the University

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The collections upon which Part I are based have been generously loaned to the University of Illinois by the Chicago Academy of Sciences for study during the preparation of this volume. These are numbers 24300 to 24400

and 25301 to 25600 of the collections in the Chicago Academy of Sciences. A duplicate set has been deposited in the museum of the University of Illinois by the Academy and are numbered P 1 to 500.

In a recent work, Salisbury[1] says of the Pleistocene record "The to-and-fro movements of the land floras and faunas must have introduced an elaborate series of superpositions, giving an elaborate, orderly, and unusual succession. The record of this succession has not been worked out in its completeness, and unfortunately there is little chance that it will be worked out in its fulness unless by the most persistent care." The present volume may be considered a contribution to the end indicated by the above statement. It is fully appreciated that it contains much that is incomplete and perhaps faulty. That it is a first attempt to cover a wide and difficult field may in a measure explain some of its shortcomings. It is thot that the bringing together of the widely scattered data and literature relative to the subject will be found useful to all students of the life of this last geological stage of the history of the earth. It is confidently hoped that its publication will inspire a desire on the part of local students to supply the deficiencies and to add the much-needed information necessary before we can write a comprehensive account of the 'Life of the Pleistocene.'

[1] Physical Geography of the Pleistocene, p. 273.

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CHAPTER I

HISTORICAL REVIEW

I. General Statement

The evidences of abandoned shore lines surrounding the Great Lakes were recognized by geologists at an early date. Colonel Charles Whittlesey,[1] as early as 1838, reported a line of beaches on the south shore of Lake Erie; Mr. Bela Hubbard[2] described a beach north of Lake Erie; Mr. James Hall[3] recognized the shore of glacial Lake Iroquois in the northwestern part of New York, and Mr. Charles U. Shepard[5] described the ancient lake beaches near Chicago but did not refer them to the agency of glacial formed lakes. These geologists realized that these old beach lines once formed the margins of large lakes, which were the predecessors of the existing Great Lake system. References to the life which peopled the waters of these ancient lakes are rare in early geological works, tho Hall[4] records the presence of Unios and drift wood in the sands of the "ridge road," in northern New York, but gives no detailed account of the species represented.

For the past fifty years or more, data have been accumulating bearing on the biota of these ancient lakes, until at the present time a varied fauna and flora has been cataloged. The earliest fauna is found (as would be expected) in the sedimentary strata of the first body of water to appear, glacial Lake Chicago, the precursor of Lake Michigan, and it is to the life of this early water body that attention is to be especially directed. Before proceeding to discuss these deposits in detail, it will be of value and interest to review briefly the work of previous investigators.

II. Previous Records of Life

1868 BANNISTER.[6]—One of the first investigators to recognize the ancient bay or lake and its southwestern outlet was Henry M. Bannister. The presence of life in the old lake deposits is apparently first mentioned by this author.

[1] Geological Survey of Ohio, 2nd An. Rep., p. 55, 1838.

[2] Geological Survey of Michigan, 3rd An. Rep., p. 104, 1840.

[3] New York Geological Survey, 2nd An. Rep., p. 310, 1838.

[4] Natural History of New York, part IV, Geology of 4th District, p. 348, 1843.

[5] Amer. Journ. Sci., (i) XXXIV, pp. 134-137, 1838.

[6] Geol. of Illinois, III, pp. 241-242, 1868. In this chapter only those works are included which refer specifically to the life of Lake Chicago or its beaches. The records of life outside this area will be found in a subsequent chapter.

A section of the shore north of the university campus, Evanston, studied by Prof. O. C. Marcy, presented the following strata:

Section of beach at Evanston

1. Surface soil	1½	feet
2. Fine sand	2½	"
3. Coarse sand	2½	"
4. Fine sand	2	"
5. Gravel	1⅓	"
6. Fine sand containing tree trunks, etc	1½	"
7. Dark colored marly bed, the lower part peaty	1½	"
8. Fine sand	3¼	"
9. Blue clay (drift)	3½	"

Mr. Bannister thus comments upon these deposits and the life contained therein: "In addition to the beds given in the section, there may be seen at one or two points, a thin seam of vegetable mould, resting immediately on the blue clay of the drift, and at the base of the true lacustrine deposits. In this seam there have been found many pieces of wood and stems of small trees, apparently cedar, and, in one instance at least, the stump with the roots penetrating the clay below to a depth of two or three feet, evidently in the position of its natural growth, thus showing that the land was at that time sufficiently elevated to support trees. Water-worn pieces of wood, also apparently cedar, are quite frequent in the stratum of sand above the clay (no. 8 of the section).

"The bed no. 7 of the section, may be followed for upward of half a mile along the beach, and is also frequently met with in digging wells in the town. An occasional fragment of a bone, and a great abundance of fossil fresh-water shells are found in this bed. The shells are all of existing species of *Unio*, *Pisidium*, *Physa*, *Lymnea*, *Planorbis*, *Valvata*, *Amnicola*, *Melantho*, *Ancylus*, etc. Immediately above this bed, and generally resting upon it, in the stratum of sand no. 6, we find many stems of large trees, chiefly oak, which seem to have drifted to their present resting place as the waters of the lake gradually encroached upon the marsh.

"In the eastern part of the county, along the lake shore, we often find the black surface soil of the small wet prairies underlaid by a bed of quicksand, containing fresh-water shells of the genera *Melania*, *Unio*, etc., which belong to the same period as the lake ridges. Instances of this kind of a prairie may be observed along the lines of most of the railroads running southwesterly from Chicago, and on the Milwaukee railroad running north. Indeed, such prairies may be seen at the present time, in the process of formation, at various points along the lake shore in this county and elsewhere. The bed no. 7 of the section was probably deposited under conditions very similar to those of the formation of these prairies, in the bottom of a shallow lagoon or marsh, and serves to show how gradual was the process of submergence or emergence during which it was formed."

No differentiation is made by Bannister of the life of the different lake periods; it is probable that the complicated stages of the glacial lakes, as understood today, were not known or comprehended at this time. The section at Evanston, quoted above, evidently includes strata referable to at least three lake stages—Glenwood, Calumet, and Toleston. No. 8 of the section is referable to the Calumet and Toleston stages; no. 7 is evidently post-Toleston; 1-6 are of Hammond age; the stratum of vegetable mould resting on the blue clay probably represents the Bowmanville low water stage.

1870. ANDREWS.[7]—Dr. Edmund Andrews, in discussing the ancient lake beaches thus refers to a peat formation underlying the Calumet beach ridge: "In fig. 4, *s* represents an ancient subaerial soil, which in many places becomes a thin peat bed, with remains of grass still on its surface, which runs entirely under the middle beach." Dr. Andrews was apparently the first person to suggest a Post-Glenwood low water stage. No mention is made by Dr. Andrews of organic remains being found in this deposit.

1888. LEVERETT.[8]—In this paper Mr. Frank Leverett discusses with much detail three ancient beaches, referring to the remains of life as follows:

Glenwood or Upper Beach

Section in Mr. Haas' gravel pit, Oak Park

1. A brown-stained gravel at the surface extending down the slope. Depth, 18-30 inches.
2. Fine gravel (unstained), 24 inches at top, increasing to 48 inches near base.
3. Sand beginning with scarcely any thickness at the top, but increasing to a thickness of 36 inches at the base of the excavation.
4. A bed of fine gravel increasing like no. 3 from 0-48 inches in thickness..
5. Fine gravel nearly four feet in thickness, which passes upward from near the east side of the excavation, assuming a nearly horizontal position beneath the crest of the ridge.
6. Sand at the bottom of the excavation becoming thicker toward the higher part of the ridge. Depth 6-36 inches.

"Molluscan shells thought to be Unios, and smaller shells have been found in no. 6, but none of these were at hand at the time of my visit. Mr. Haas afterwards sent an oyster shell which was embedded in no. 6, and near itwas the tooth of a mammoth. If the oyster shell has not been introduced it suggests much as to a salt water lake. It is possible that the shells thought by Mr. Haas to be Unios, were salt water mollusks. We learned of no other instances of the occurrence of molluscan remains along the upper beach."

A personal examination of this gravel pit failed to reveal animal life of any kind. The oyster shell was undoubtedly introduced artificially; there is no evidence of a postglacial intrusion of the sea in this region.

[7] Trans. Chicago Acad. Sci., II, p. 15, 1870.
[8] Trans. Wis. Acad. Sci., III, pp. 177-188, 1888.

Calumet or Middle Beach

The peat bed (page 184) mentioned by Dr. Andrews is discussed at some length. It was found upon examination to extend completely under the Calumet ridge and even to underlie certain portions of the lower beach. The peat bed is said to contain the mangled remains of wood. Leverett could trace this peat bed only a short distance west of the beach ridge (Calumet), but the writer has found it extending westward for over a mile. Leverett was unable to formulate a theory to account for the burying of the peat bed beneath the lake beaches of sand and gravel. Mr. Leverett states that near Summit "we are told that shells of Unios and of smaller mollusks, also fragments of wood have been found at the base of the gravels, but none were at hand at the time of our visit." The writer has collected postglacial material at this locality, and the record is, therefore, authentic.

Toleston or Lower Beach (page 188)

A cut in the beach at Evanston gave the following section (made by Dr. Oliver Marcy):

1. Surface soil, sandy	1½	feet
2. Brown sand and fine gravel	2½	"
3. Coarse gravel, stratified	2½	"
4. Fine sand	2	"
5. Gravel containing bones of deer	1⅛	"
6. Fine sand containing oak logs	1½	"
7. Peat or carbonaceous earth, with a marl bed containing molluscan shells in the lower portion, or interstratified with the peat	1½	"
8. Gravel	1½	"
9. Humus soil with cedar stumps and logs	4-6	inches
10. Yellow clay laminated and contorted, containing pockets of gravel	3½	feet
11. Blue pebbly clay	2	"
Height of bluff	22	"

"The bone is a portion of the femur of a deer (species not determined.) The oak wood is well preserved but the cedar is mangled and shivered. Professor Marcy also has specimens of mollusks collected from the marl beds associated with the peat in no. 7 of the above section. The following are specifically identified: 1. *Planorbis campanulatus*; 2. *Planorbis parva* (*parvus*)[9]; 3. *Amnicola linosa* (*limosa*)[9]; 4. *Pisidium dubium*; 5. *Cyclas sulrata* (*Sphærium sulcata* = *simile*).[9] Unios of various sizes occur, which are not specifically identified. There are also other molluscan remains not included in the above species."

[9] These corrections are the author's. The section studied is the same as that mentioned by Bannister on a previous page.

1891. PENHALLOW.[10]—The plant remains found by Dr. Marcy in the Evanston beach deposits were submitted to the late Prof. D. P. Penhallow, who thus comments upon them: "By comparison with recent species of *Quercus*, this fossil appears to most nearly approach *Q. primus* and *Q. garryana*, the affinities being nearer the former than the latter. Such differences as could be definitely established, were found in the length of the ray cells, the abundance and form of the markings on the vessels, and the number and size of the medullary rays. These differences are such as to render exact identification with modern species hardly probable, and as a suitable means of distinction and recognition I would therefore propose for this fossil the name of *Quercus marcyana*."

"The wood of the *Picea* was cut with as great facility as the oak, and while the transverse sections were quite clear as to the details of structure, the longitudinal sections also gave numerous well preserved details, from which a series of drawings were prepared.

"So far as the details have been made out, they seem to establish affinity with *Picea sitchensis*, but as in the case of the *Quercus*, the differences are such as to cause hesitation in establishing exact identity between them. Were it possible to establish identity between the two, then there would be good evidence to show the extent to which the area of distribution of *Picea sitchensis* has contracted within recent geological times, since this is now essentially confined to the Pacific coast, from Alaska to Mendocino, California, extending inland not more than fifty miles. I deem it expedient to distinguish this fossil by a separate name, for which I would suggest *Picea evanstoni*."

Prof. Penhallow says further, "The local evidence is such as to confirm the view that the *Picea* grew upon the spot where found, sending its roots down into the clay." The bones of a mastodon are also said to have been found on or in the peat layer labeled no. 4 of Marcy's section (see Higley and Raddin, p. xiii, figure 2).

The *Picea* may possibly be the same as the material identified as *mariana* or *canadensis* from deposits recently explored near Bowmanville. Oak leaves were also found in the Bowmanville deposits but so imperfect that identification was impossible. They may have been the same as the *Quercus* described by Penhallow.

1891. HIGLEY AND RADDIN.[11]—In the introduction to this paper (pages XIII, XIV, XV) the three major beaches are discussed in relation to the flora, past and present. The section at Evanston, studied by Prof. Marcy and

[10] Trans. Roy. Soc. Canada, IX, pp. 29-32, 1891.

[11] Bull. Chi. Acad. Sci., II, No. I, 1891.

discussed by Bannister and Leverett, is graphically shown (see plate IV, 1) and commented upon as follows:

Section of bluff at Evanston

10. Sandy	1.50 feet
9. Brown sand and fine gravel	2.50 "
8. Coarse gravel, stratified	2.50 "
7. Fine sand	2.00 "
6. Gravel	1.33 "
5. Fine sand	1.50 "
4. Peat and carbonaceous earth	1.50 "
3. Gravel and sand	3.25 "
A. Humus soil, organic matter, very thin	
2. Laminated yellow clay	3.50 "
1. Clay (bowlder)	2.00 "
Total height	21.58 "

"For ten years previous to that time (1884), according to the best information that could be obtained, the shore had washed away about two rods each year. At the time the section was made, a northeast storm had produced a clear vertical section of the bluff. *L* (Lake Michigan) indicates the water surface. For two feet at the foot of the bluff, the shingle of the shore covered the clay. Above the shingle was a vertical section of the upper portion of the clay; three and one-half feet as shown in the diagram. At *A* on the surface of the clay, five and one-half feet above the water, was an old soil. The layer of organic matter was very thin, but on it, was much coniferous wood, some of which appeared to grow on the place where it was found. No other kind of wood was found at this horizon. Three and a half feet of nearly horizontally stratified sand covered this soil. Then at 4, in the diagram, there was one and a half feet of peat. In the upper surface of the peat, were many fresh water shells. Nine different genera were identified, all of which were existing species. They were *Planorbis*, *Valvata*, *Physa*, *Lymnia* (*Lymnæa*) etc., with fresh water bivalves, so decomposed that it was impossible to determine the species. Upon this peat and lying more closely upon it than is indicated in the figure at 5, were trunks of oak trees in a layer of fine sand. This layer, 4, with the oak trunks lying on it or in it, extends under all the village of Evanston east of the railroad. At 6 was a bed of coarser gravel in which were found in 1863, a little distance from the place of this section, pelvic bones which have been referred to the deer.

"The parts of the section above this are of beach or bar structure and need no particular description. Specimens of the coniferous wood from the soil *A*, and of the oak from 5, were sent, in 1890, to Prof. D. P. Penhallow, of Magill University, Montreal, who on examination microscopically replies, "No. 1 is not an *Arbor Vitae*, but a *Picea*. Both this and the oak cannot be referred

to any modern species, though the former approaches *P. sitchensis*, and the latter *Q. falcata* and *Q. primus*."

"The genus *Picea* (spruce) does not now grow within several hundred miles from the locality, and the species of oaks which are now found upon the surface of the ridges are neither *falcata* nor *primus*. The indication is that previous to the beginning of the Recent beach, a climate and flora prevailed like that in Alaska. Then when the peat began to form at the time as indicated by the peat layer at 4, the spruces had disappeared and a species of oak had taken their place, and now these have disappeared and other oaks have replaced them. This lower soil in the section at A, lying upon the clay, indicates a time when the surface of the waters were as low relatively to the land at this place as now. Afterwards the waters rose as high as the Upper beach. After the Upper beach was formed, the waters subsided to the Middle beach, and again to the Recent beach. The coniferous wood probably grew before Lake Michigan was definitely formed.

"The oak is not completely decayed. The outside wood of the trunks is spongy, but the central portions are tough and fibrous. Borers then as now infested the trees.

"Horizon 5, just above the peat, marks the upper or later limit of the Mastodon. It was on this soil about six years ago that the bones of a mastodon were found in Chicago, on the south side of Wicker Park near Milwaukee Avenue. They were covered by thirteen feet of silt, or as Dr. Andrews suggests, loess. The bones consisted of part of a jaw, teeth, and parts of a few other bones, and are now in the collection of the Chicago Academy of Sciences.[12] There is in the Museum of the College of Liberal Arts of the Northwestern University a fragment of fossil ivory received from the late James L. Milner, afterward connected with the U. S. Fish Commission, taken from a gravel pit excavated in the Middle beach in Evanston when the Milwaukee Branch of the C. & N. W. R. R. was constructed. From what level it was taken, is not now known. The pit appears to have been excavated to the clay, and the fossil was probably on the same stratum as that at Chicago.

"There is no positive evidence that the waters of the lake were salt water at the time the Upper beach was deposited. No shells have been found in the beach by which the character of the waters could be determined, but the presence of sea shore plants now upon the lake shore, and the existence of the marine *Mysis* in the waters of the lake, indicate that at some time, salt water has existed where Lake Michigan now is.[13] The old bay of the lake whose margins are marked by the Upper beach, left some silt on its bottom, and in these silts have been found fresh water Unios. We have fragments of such shells

[12] A careful search has failed to reveal the specimens mentioned.

[13] This statement is not borne out by later investigations. There is no reason to believe that the waters of the lake were ever salt.

taken from the silts at the corner of West Monroe and Morgan streets in Chicago."

Higley and Raddin recognize a low water stage, but place it previous to the formation of the Glenwood beach, whereas the evidence now at hand leads to the conclusion that the low water stage followed the Glenwood beach formation and that the waters rose subsequently only to the Calumet beach level These authors also call attention, apparently for the first time, to changes of climate during the existence of Lake Chicago, as evidenced by the remains of the oak and spruce.

1895. UPHAM.[14]—Mr. Upham thus writes of the organic remains contained in the deposits at Evanston: "Fresh-water shells are found abundant in the 15-foot beach at Evanston and elsewhere southward through Chicago. All species obtained, representing ten or more genera, are still living in this region. Wood of oak and cedar, and the thigh of a deer, have been also found in the same beach at Evanston." The peat bed of the 15-foot beach is also recognized by this author as having been formed before the 30-foot or middle beach.

1897. LEVERETT.[15]—In this paper Mr. Frank Leverett presents considerable information concerning the presence of life in the deposits under discussion.

Glenwood stage (pp. 70-71)

Mr. Leverett discusses the gravel pit at Oak Park (Mr. Haas') and gives the same section published in his previous paper (see 1888). Mr. Leverett comments further on the molluscan shells. "Upon visiting the region again and inquiring particularly into the circumstances, there seems little question that the shell was picked up near the base of the pit by some of the workmen, but it was found that there are a few Indian graves on the bar, which extend down nearly to the level of the base of the pit. The shell, therefore, may have been introduced at the time of burial of some brave warrior, or it may have been of more recent introduction. This is apparently the only place along the entire length of the upper beach where molluscan shells have been found, and this negative evidence strengthens the view that the shells at this point may be intrusions. Remains of terrestrial life have also been found here. Mr. Haas preserved fragments of the tooth of a mammoth found in the gravel pit at a depth of several feet. These fragment are waterworn, and it seems, therefore, quite probable that they were imbedded during the formation of the beach.

Post-Glenwood Low Water Stage (page 71)

"After the Glenwood beach was formed the lake appears to have withdrawn from the plain between the beach and the shore of Lake Michigan, in Illinois. How much farther north it withdrew is not accurately determined.

[14] Amer. Journ. Sci., (iii), XLIX, p. 6, 1895; 23rd. An. Rep. Geol. Surv. Min. p. 168, 1895.
[15] Bull Nat. Hist. Surv., Chi. Acad. Sci., II.

Professor Chamberlin recognized evidence of emergence between the formation of this beach and the second beach, in Southeastern Wisconsin. That it withdrew so much in the northern end of the Lake Michigan basin as in the southern seems improbable from the evidence drawn from tilting, it being found by Mr. F. B. Taylor that that portion of the basin has been uplifted more than the southern. Whether this emergence is to be connected with the lake stage, known as the Algonquin, is not yet ascertained, though that seems a probable correlation.

"The evidence for this emergence within the Chicago area is found in beds of peaty material that occur beneath gravel of the succeeding lake stage, as long since noted by Dr. Andrews and discussed in his paper cited above. In Wisconsin the evidence is in clay beds, which seem to have been left in a retiring water body, and which are covered by beach deposits of the succeeding lake stage, as pointed out by Prof. Chamberlin in his official report of the Wisconsin Geological Survey. There is need for further study of this interval in the lake history before conclusions of much consequence can be drawn.

"An excellent exposure of the structure of the bar noted above (Calumet beach) is found immediately north of Evanston, where the lake is undermining the bar as well as subjacent deposits. The beach sands and gravels rest upon a bed of peat, which was noted by Dr. Andrews and interpreted by him to be the accumulation of a marsh or partially submerged land surface. The peat not only underlies the bar under discussion, but extends eastward across the interval between it and the Third beach. Its level is no higher than that of the Third beach, being but 12 to 15 feet above the present level of Lake Michigan. The peat is in places several feet thick, but at the point where the bar comes out to the lake shore it has a thickness of only 3 to 6 inches. It contains pieces of mangled wood and has been disturbed by waves. Between the peat and the yellowish blue till, which forms the base of the exposure, there is a gravelly sand 6 to 18 inches in thickness, which appears to be a lacustrine deposit. The peat is immediately overlain by about 5 feet of sand, above which there is a bed of coarse gravel. The gravel is thin near the borders of the bar, but has a thickness of 11 to 12 feet beneath the highest part. It is capped by a thin deposit of sand and has layers of sand interstratified with it in its thickest part. The presence of this gravel makes it impossible to suppose that the old land surface has been buried by the drifting of material from the lower beach. There seems no escape from the conclusion that the lake stood at a lower stage than the level of the second beach before that beach and the bar under discussion were formed."

Calumet Stage (page 73)

"Occasional reports of the discovery of a molluscan shell in this beach have come to my notice, but none have been personally noted. In this respect it is similar to the upper beach, and in striking contrast with the next lower beach, which is full of fossils."

Toleston Stage (pages 76-77)

Leverett refers to the section studied by Marcy in 1864 and adds a section studied by himself in 1887, after the beach had been eroded from 75 to 100 feet (plate IV, II).

Section of Beach at Evanston made in 1864

1. Surface soil, sandy	1⅓	feet
2. Brown sand and fine gravel	2½	"
3. Coarser gravel, stratified	2½	"
4. Fine sand	2	"
5. Gravel, containing bones of deer	1 1/3	"
6. Fine sand, containing oak logs	1½	"
7. Peat or carbonaceous earth with a marl bed containing molluscan shells in the lower portion or interstratified with the peat	1½	"
8. Gravel	3¼	"
9. Humus soil, with stumps and logs (coniferous)	½	"
10. Yellow clay, laminated and contorted, containing pockets of gravel	3½	"
11. Blue, pebbly clay	2	"
Height of bluff	22	feet

Section of Beach at Evanston in 1887

	Feet	Inches
1. Yellowish-red, iron-stained sand	3 to 5	
2. Band of bog iron ore, granular		4 to 6
3. Gravel, with beds of sand included (the stratification is very irregular in thickness and assorting very imperfect)	5 to 7	
4. Coarse sand, not calcareous		6 to 12
5. Calcareous loam		3
6. Yellow clay, very calcareous, with leaves imbedded		3
7. Carbonaceous band, not calcareous		2
8. Yellow calcareous clay, similar to No. 6		4 to 6
9. Band of carbonaceous material, not calcareous		2
10. Brown sand, with twigs and peaty material		8 to 10
11. Water bearing sand and talus-covered slope	8	
Height of bluff	20 to 22 feet	

"The calcareous clays No. 6 and 8, of the last section, and Nos. 6 and 7 of Dr. Marcy's section, contain numerous gasteropod shells. Dr. Marcy has collected a large number of shells from this horizon, among which there are *Unios*, apparently of several different species, but not specifically identified. Mr. C. T. Simpson has identified nine different genera of mollusks, all of existing species, found in No. 7 of Dr. Marcy's section. *Planorbis* and *Lymnea* are very abundant. Prof. D. P. Penhallow has identified two wood specimens, one a new species of Picea (*Picea evanstoni*), the other a new oak (*Quercus marcyana*) (I). The bone of the deer, found by Dr. Marcy, is a portion of the femur. The writer has found many localities in the sandy portions of this beach, where

molluscan shells abound. Nearly every exposure in the sandy district west of the beach, from the main part of the city of Chicago southward to Englewood exhibits them. This beach is, therefore, in striking contrast with the two higher beaches, which contain few remains of aquatic life.

"An excellent artificial section across this beach, made by the Fullerton avenue conduit, which leads from the Chicago River eastward to Lake Michigan, across the north part of Chicago, is discussed above. The deposit throughout is mainly sand, but some gravel is encountered. Shells of *Unios* and other mollusks were noted at frequent intervals throughout nearly the whole width of the deposit. Beneath these beach deposits there is everywhere a pebbly blue-gray clay, apparently an unmodified glacial till. Some of the sewer ditches in Hyde Park, west of Grand boulevard, have reached peat deposits below sand, at a level a few feet above the lake. Wood has often been found in the sand west of this beach in Chicago."

The sections mentioned above contain strata referable not alone to the Toleston stage, but to the previous stage, as already noted. The peat deposits in Hyde Park are evidently referable to the Post-Glenwood or Bowmanville stage.

1897. BLATCHLEY.[16]—Mr. W. S. Blatchley in discussing the geology of Lake County, mentions glacial Lake Chicago. On page 38 silts and marly clays are mentioned but no organic remains are recorded. On page 89 the presence of the mammoth and mastodon are noted.

1898. BAKER.[17]—Mr. Frank C. Baker mentions the following species as occuring in postglacial deposits:

Quadrula trigona. Corner Wrightwood Avenue and North Clark Street.
Quadrula undulata. Corner Frederick and North Clark streets.
Quadrula species. Hall Street.

These three species were found in excavations for buildings.

Pleurocera elevatum. Corner Sheffield and Lincoln avenues.
Goniobasis livescens. Corner Sheffield and Lincoln avenues.
Goniobasis livescens. Balmoral Avenue north of Bowmanville.

At Willow Springs, in the river bank, the following species were found:

Anodonta grandis
Unio gibbosus
Quadrula rubiginosa
Sphaerium simile
Sphaerium stamineum
Planorbis trivolvis
Physa ancillaria warreniana
Amnicola limosa
Amnicola emarginata

The additional species mentioned in this paper belong to the deposits of the recent stage. It is impossible to correlate these fossils with any one of the

[16] An. Rep. Geol. and Nat. Res. Ind. XXII.
[17] Bull. Nat. Hist. Surv., Chi. Acad. Sci., III, part I, p. 23.

deposits of the lake stages, as no data are now available for this purpose. The Unios were probably taken from deposits of the Toleston stage. Some of the gastropods were evidently from the Hammond or Englewood stages.

The following species were identified for Prof. Marcy, who collected them in stratum number 7 of his Evanston section.

Galba palustris	*Physa warreniana*
Galba caperata	*Ancylus* species
Galba reflexa	*Goniobasis livescens*
Planorbis trivolvis	*Pleurocera elevatum*

1899. SALISBURY AND ALDEN.[18]—In this publication the authors make reference to the presence or absence of life in the several lake stages.

Glenwood Stage (page 39)

"No satisfactory evidence of life has been found in the waters of the lake at the Glenwood stage. This is as would be expected in waters mostly derived from the melting of the great ice-sheet."

Post-Glenwood Low Water Stage (page 40)

Reference is made to an interval of emergence preceding the Calumet stage but no life is recorded.

Calumet Stage (page 43)

"In connection with the evidence of a withdrawal of the water from the Chicago plain at the close of the Glenwood stage, and its consequent submergence by the waters of the Calumet stage, the finding of evidences of life in these lake deposits is of especial interest. The occurrence of shells in the Calumet beach deposits at Summit and near New Buffalo, Michigan, has been reported, but no definite information has been secured concerning them. The only place where definite evidence of life has been found about Chicago is at the farm of Mr. J. H. Welch, about one and one-half miles southwest of Chicago Lawn. The Calumet shore-line was spoken of as being marked by a well-developed ridge of sand and gravel swinging in a broad curve from Summit southwestward about the north end of the Blue Island ridge. In Mr. Welch's field, just northwest of the point where this ridge is cut by the Belt Railway, there have been found numerous molluscan shells, and one specimen of coral. An examination of these specimens showed them, without exception, to be of marine species, whose present range is between Prince Edward Island and the West Indies. With the specimens which could be identified there were many fragments so well worn and thoroughly perforated as not to permit of identification. The character of the evidence which these shells seem to afford is of such a radical nature as to excite great interest, and conclusions must be drawn with extreme caution.

[18] Bull. Geol. Soc. Chicago, I.

"The question is, were the shells left in their present position by natural agencies? To say that they reached their present position by natural means, is to say that the waters of Lake Chicago at the Calumet stage were salt. This would seemingly require the subsidence of this and surrounding areas to such a level as would allow the incursion of the sea over this part of the interior of the continent, and their subsequent elevation to the present altitude of 620 feet above tide, within very recent geological time.

"It is true that this is not the first or only suggestion of such a subsidence and marine incursion. Dr. R. W. Ells[19] of the Geological Survey of Canada, has recently brought forward evidence to show that the ocean extended westward throughout the upper Ottawa basin in post-glacial time, leaving marine deposits which are now 1000 feet above the sea level. Dr. Bell[20] also records the presence of marine deposits north of Lake Superior, along the Kenogami River, at an elevation of 450 feet above sea level. It is not unreasonable that the subsidence of the area about Chicago should have occurred as a part of the more general subsidence of which these marine deposits to the north and northeast seem to be evidence.

"The presence of the fossils mentioned above might be accounted for by artificial introduction. They might have been thrown there by white men or introduced in a fertilizer used on the soil. The well-known trading of the Indians of the northern interior with the south and east coast might account for their having been left here, before the coming of the white men. They might have been left on the beach of Lake Chicago by the Indians of that time, and have been water-worn and buried by the waves of its shore. It should also be noted that the physical relations indicate that the Calumet beach marks the border of a lake which seems to have stood sufficiently above sea level to maintain a strong current through its outlet, which seems incompatible with the occurrence of marine life in its waters.

"On the other hand, the water-worn and fragmental condition of a large part of the marine shells found on the Calumet beach, the thorough perforation of many specimens by sea-borers, the occurrence of very delicate, tiny shells in the sand filling the coils of the larger gastropod shells, together with the statements of Mr. Welch, that he himself cleared the ridge of its native trees and underbrush, broke the sod, and has lived there for nearly thirty years, that he never used any fertilizer containing shells, that the only evidence of Indian residence he has ever found was a single arrowhead, that he has ploughed up and gathered the shells ever since the ground was broken—all these facts are against the idea of an artificial introduction of the shells, and favor the idea of deposition *in situ* by marine waters. The southern range of all the species found would also seem to preclude the idea of their introduction from the north

[19] Bull. Geol. Soc. Amer., IX, pp. 211-222, Feb. 1898.

[20] Report of Progress, Can. Geol. Surv., 1895, VI, p. 340.

or northeast, for the shells found by Drs. Bell and Ells are all of Arctic species. If the shells be evidence of an incursion of the sea, their occurrence, so far as known on this second, or Calumet beach only, would indicate this stage (or a part of it) as the time of the incursion, and the southern range of all these species at the present day would indicate that the incursion was not from the northeast through the St. Lawrence embayment, but from the south, through a Mississippi embayment.

"In view of these apparently conflicting considerations, final judgment concerning the interpretation of the shells must be suspended until further evidence is forthcoming."

The finding of marine fossils in the fields near Chicago Lawn raised a serious question as to their origin. The presence of certain crustacea (*Mysis*) in the lake as well as of such plants as the beach pea (*Lathyrus maritimus*), the beach plum (*Prunus maritima*), and the seaside spurge (*Euphorbia poligonifolia*) has led several writers to the conclusion that the waters of Lake Michigan were once salt. The presence of these plants and crustaceans are, however, not sufficient evidence on which to build a theory of this kind. At first it might be thot that the fossil shells found on Mr. Welch's farm offer indubitable evidence of the presence of marine waters at this stage of postglacial history There are, however, several physical factors to be taken into account. The species recorded are all of southern distribution, living plentifully in the Gulf of Mexico or the waters of the Atlantic Ocean bordering the southern and southeastern coast of the United States. Therefore, the incursion of the sea must have been from the south by way of the Mississippi Valley and not from the northeast by way of the St. Lawrence Valley.[21] If there was such an incursion, there should certainly be evidences in the territory lying to the south of the area in

[21] The species found on Mr. Welch's farm are noted below. A list of a few species from the Montreal marine deposits is also given, in a parallel column; the difference in the two faunas is at once manifest.

Chicago	*Montreal*
Mollusks	Mollusks
Ostrea virginica	*Saxicava arctica*
Arca transversa	*Mya arenaria*
Venus cancellatus	*Mya truncata*
Venus mercenaria?	*Macoma balthica grœnlandica*
Pecten sp. (*Chlamys irradians?*)	*Cardium grœnlandicum*
Gnathodon cuneatus	*Mytilus edulis*
Fulgur perversus	*Chlamys islandicus*
Cerithium species (apical whorls)	*Acmæa cocca*
Cerithiopsis species " "	*Littorina palliata*
Coral	*Scala grœnlandica*
Oculina robusta	*Lunatia heros*
	Tricholropis borealis
	Buccinum undatum

question; but no evidence has been found which would support such a contention. All available data lead to the conclusion that the shells found on Mr. Welch's farm were not deposited there by natural means. If this be true then how did the shells come to be in their present location?

Some time ago, (1910) Mr. A. Scharf, an archæologist who spends considerable time locating Indian camp sites, discovered a few marine shells at Palos Springs, in a deposit 300 feet west of the postoffice. This is on the Glenwood beach, and would lead to the conclusion that the waters of this stage were salt. Four species were found: *Arca ponderosa*, *Cardium muricatum*, *Ostrea virginica*, and *Venus cancellatus*. The last two species were also found in the Chicago Lawn deposit, but the first two are new. All are southern species. With these were found flint chips! It seems quite evident from subsequent study, that all of these marine shells were artificially introduced by man, and mark old camp sites. The specimens were doubtless obtained by trading with the Indians of the east and southeast, and were used for making wampum, as well as ornaments. The Omaha Indians used pieces of the large conch shell (*Strombus gigas*) to ornament the robes of their medicine men. The writer has observed the presence of oyster shells (*Ostrea virginica*) in the fields bordering the north shore channel, especially in the neighborhood of Bowmanville, where Indian relics of various sorts are common. Dr. Stuart Weller, of the University of Chicago, has examined the sand contained in the gastropod shells found at Chicago Lawn, and finds it to be different from the sand of the Calumet beach, and of the Chicago region. The proof of artificial origin at once settles the question of the status of these shells and removes them from further consideration in connection with the life of Lake Chicago.

Toleston Stage (page 51)

"In striking contrast with the Glenwood and Calumet beaches, the Toleston beach contains abundant traces of life closely related to the life of Lake Michigan, if not identical with it."

1899. LEVERETT.[22]—In this publication reference is made to the presence of life in the old beach deposits.

Glenwood Stage (page 440)

The statement made in a previous work, concerning shells in Haas' gravel pit, is repeated. Leverett adds: "Another locality in which supposed Unio shells have been reported is found in a marsh on the inner side of the beach north of New Buffalo, Michigan. Mr. Glavin, formerly county surveyor of Berrien County, reports having observed shells as large as the ordinary clam shell in ditching near the borders of this marsh. He has, however, preserved none of the shells, and possibly may be mistaken in his identification. So far

[22] Monograph 38, U. S. Geol. Surv., Chapter XI.

as known to the writer, these are the only places along the entire length of the upper beach where molluscan shells have been reported, and none have been personally found, though search has been made for them in several exposures and excavations. There appears, therefore, to have been a great scarcity of molluscan life in this stage of Lake Chicago." The deposit spoken of above should probably be referred to the Toleston stage, as herein understood, and not to the Glenwood stage. This marsh was probably a long, narrow bay, occupying the territory now drained by the Galien River.

Interval of Emergence (page 440)

A low water Post-Glenwood stage is recognized, the data presented in a previous paper (1897) being repeated.

Calumet Stage (page 444)

The statement of 1897 is repeated.

Second Emergence (page 446)

A second period of emergence (possibly preceding the Algonquin Lake stage) is recognized.

Toleston Stage (page 450)

The information contained in the previous paper is repeated.

1902. ALDEN.[23]—In the Chicago Folio, Alden repeats the statements made in the Bulletin of the Chicago Geographic Society (1899).

1905. ANDERSON.[24]—In this paper, attention is called to the finding of proboscidian fossils in Cook County.

"Evanston.—The tooth of a mammoth was taken from a gravel pit near Evanston. It was placed in the museum of the Northwestern University. (Reported by Prof. U. S. Grant, Northwestern University)

"Glencoe.—A fragment of a mastodon tooth four and three-fourths inches long was dug up by Mr. James Robertson while ditching in glacial drift at Glencoe. The fragment, which was from the proximal end, is now in the possession of Mr. Walter O'Neill of Lake Forest.
(Reported by Prof. James G. Needham, formerly of Lake Forest College)

1906. GOLDTHWAIT[25] (page 420) calls attention to the shells found by Dr. Marcy and others in the Toleston beach at Evanston, remarking that the presence of these mollusks indicates a lake with less frigid waters than during the Calumet or Glenwood stages.

1907. GOLDTHWAIT[26] (page 118) mentions the presence of life in the Toleston beach at Evanston, and says, "In the deposits of the 24-foot beach at Evanston,

[23] U. S. Geol. Surv., Atlas No. 81.
[24] Augustana Library Publications, No. 5, 1905.
[25] Journ. of Geology, XIV, pp. 411-424.
[26] Bull. Wis. Geol. & Nat. Hist. Surv., XVII, 1907.

Illinois, a considerable number of small shells was collected by the writer, which confirm the earlier observations of Marcy, Alden, and others, that the Toleston beaches show abundant signs of life. The shells are all of existing fresh-water types. As no such fossils have been discovered in the 40 to 60-foot beaches of Lake Chicago, it is inferred that the 24-foot stage was one whose waters were not frigid, as in Lake Chicago, but in which the Chicago district was much more remote from the ice, as was the case in Lake Algonquin. Shells of similar species, but of larger size, were also found in April, 1906, in beach ridges of the Algonquin group (18 feet above the lake) at Huronia beach, near Port Huron; and they have been collected from the Algonquin beach in other parts of eastern Michigan, by C. A. Davis and other members of the Michigan Geological Survey."

The species of shells from the beach at Evanston, as identified by Mr. Bryant Walker, are as follows:

Valvata tricarinata	*Planorbis parvus*
Amnicola limosa	*Pisidium* (*3 species*)

1908. GOLDTHWAIT.[27]—Life during the Calumet stage is suggested by Goldthwait, who says (page 63), "Near Beach station the Calumet ridge appears on the brink of the Toleston bluff, and runs northward with short interruptions to the State line, never far from the bluff of the lower stage. Through Zion City it is followed by Elizabeth Avenue. Near Winthrop Harbor it was cut away, during the Toleston stage, for half a mile. Although usually a low, faint feature, and subdued by ploughing, it is broad and strong between Zion City and the Camp Logan road. Here a peaty deposit, lying between the Glenwood and the Calumet beach ridges, contains a great abundance of fresh water shells.

"Since these shells are all of living species and none have been found either here or elsewhere within stratified deposits of the Calumet beach, they seem not to belong to Calumet time, but rather to the present. There are no certain traces of life in the lake during the Glenwood and Calumet stages."

The molluscan species, as identified by Bryant Walker, are as follows:

Galba reflexa	*Planorbis trivolvis*
Physa elliptica	" *bicarinatus*
Pisidium species	" *parvus*

The shell deposit cited above is, as suspected by Goldthwait, quite recent, representing the bed of a swale or summer-dry pond. The writer has examined many such deposits in this and other localities.

Life during the Toleston stage is reported as abundant by Goldthwait. Of the sections observed on the campus of the Northwestern University, he says (page 65): "A recent cross-section in the bluff, where the ridge runs out to the

[27] Bull. Ill. State Geol. Surv., No. 7, 1908.

lake, showed one foot of peat about 5 feet above the lake, beneath the Toleston gravels. Below the peat is a compact deposit of very fine gray sand of unknown depth. A single shell was found in the sand close to the peaty layer. A section studied by Leverett in 1888 showed similar peat layers, with associated shell-bearing clays nine feet above the lake. Dr. Oliver Marcy, in 1864, made a record of an exceptionally good exposure in the cliffs, which were then unprotected by the piers and artificial beach. The peat, a clay bed containing molluscan shells of nine genera (all existing species) was found ten feet above the lake. Farther down, on the contorted glacial clays, was found a 'humus soil, with stumps and log (coniferous),' six inches thick and buried by three feet of gravel. A cellar excavation on Davis Street, Evanston, recently showed a peat bed between the boulder clay and the over-lying Toleston gravels and sands. Minute fibrous rootlets could be seen penetrating the till at the base of the peat, indicating that the deposit is *in situ*, presumably a land surface beposit. If so, it registers a stage of low water preceding the Toleston. A marl bed near the Toleston gravels here, contains an abundance of shells."

The deposits cited above probably belong to several stages and should not all be referred to the Toleston episode.

1910–1912. BAKER.[28]—The papers of this author outline the postglacial life of the Chicago region substantially as presented in the present work.

1912. HAY.[29]—In this paper Hay discusses the Pleistocene Period and its vertebrates and incidentally refers to a skeleton of *Amia calva* from the bed of Lake Chicago and the presence of the mastodon and mammoth in parts of Cook County, Illinois, and Lake and Porter counties, Indiana.

1914. PEATTIE.[30]—In this paper reference is made, incidentally, to peat deposits and other evidences of life. Some of these may be interglacial. It is evident that much valuable information has been available from these well-boring and excavation records which has not been made to bear more directly on these problems of Pleistocene life distribution because the material has not been examined by those trained to interpret such data.

1915. LEVERETT[31] comments as follows on the peaty deposits found at Evanston and Bowmanville: "Deposits of peaty material found under portions of the Calumet beach have been interpreted to signify that the lake level stood lower than the Calumet beach at a time prior to the development of that beach. A conspicuous burial of peat under the gravel of the Calumet stage of the lake is found in Evanston, Ill., where the gravel extended southward as a bar into a bay that stood back of the present city. A recent exposure of peat below the Calumet beach at Bowmanville is noted by F. C. Baker. However, although

[28] Science, n.s., XXXI, pp. 715-717, 1910; Trans. Ill. Acad. Sci., IV, pp. 108-116, 1912
[29] 36th An. Rep. Dept. Geol. & Nat. Res. Ind., pp. 552, 710; 700-750, 1912.
[30] Journ. Western Soc. Eng., XIX, pp. 590-611, 1914.
[31] Mon. 53, U. S. Geol. Surv., p. 356, 1915.

the presence of peat under the gravel suggests a lower stage of water it can scarcely be said to prove it conclusively, for a bar might be extended out over a peaty deposit standing at the same level as the lake and might press it down and thus give it a lower level than it had while in process of growth. At the Evanston locality this interpretation would seem very plausible, for the bar was built out into water of considerable depth by southward moving currents. Other peaty deposits are extensively covered by the gravels of the Calumet beach along the bluff of Lake Michigan between Michigan City, Ind., and New Buffalo, Mich. In this place there seems to have been no bar, but a regular beach. The peat ranges from about 15 feet above the lake down to the water's edge. The layers, few of which are more than 6 inches thick, are interbedded with sand. One layer standing 12 to 15 feet above the lake is traceable continuously for fully half a mile along the shore about 2 miles southwest of New Buffalo. Near Michigan City the peaty layers are continuous just above the water's edge for a mile or more. Pebbly sand above the peaty beds in places reaches an elevation of 30 feet or more above the lake or nearly to the level of the Calumet beach. The sand evidently was deposited during the development of that beach and the peat is certainly as old as the beach. The beach may have been extended out over a peaty deposit, as was suggested in the case of the Evanston deposits, but the conditions on the whole do not strongly favor this view. If a lower lake level preceded the development of the Calumet beach other evidence than that from the buried peat deposits should be found. For instance, the valleys which entered the lake at this lower stage should have been cut to a level below the Calumet beach and then the beach should have been built across the beds of these channels as the Whittlesey beach was across the valleys that were cut to the level of Lake Arkona in eastern Michigan."

Of the Algonquin beach Leverett says,[32] "The Algonquin beach carries in a few places molluscan shells, and this beach of Lake Chicago is in places richly supplied with these shells. In this respect it contrasts with the Calumet and Glenwood beaches, from which molluscan remains have as yet been reported at but one locality, near Bowmanville, north of Chicago. Sea shells found by Alden and an oyster shell found by the writer may have been brought in by human agencies."

Leverett questions the interpretation of the writer, in placing the peaty deposits of the Chicago region in a stage preceding the formation of the Calumet beach. The data for such interpretation are presented in the following chapter.

1916. SUDWORTH[33] mentions the occurrence of spruce in the postglacial deposits of Chicago, the reference being from Dr. Berry, to whom material was sent by the writer. "Cones of both *Picea canadensis* and *P. marina*, the

[32] *Op. cit.*, p. 357.

[33] Bull. 327, U. S. Dept. Agric., p. 3, 1916.

white spruce and black spruce of today, are abundant in postglacial deposits at Chicago, Ill."

1917. WRIGHT[34] seeks to explain the elevated beaches and the buried peat deposits by the varying volume of water flowing through the different outlet channels across Michigan. "The most difficult facts to account for are numerous peat deposits underneath the Calumet or second beach. To explain this accumulation of peat in that position, resort has been had to the supposition of a temporary land elevation.

"But a simpler explanation follows from considering the variations in amount of water passing through the Chicago outlet, occasioned by the opening of the various channels giving access to Lake Michigan of the vast amount of water stored up in the glacial lakes which occupied the Lake Erie basin. Lake Maumee stood 200 feet above Lake Michigan and was lowered 50 feet when the Ubly outlet was opened. Lake Whittlesey stood 150 feet above Lake Michigan and extended over an area of several thousand square miles. This was lowered 50 feet on the opening of the Saginaw outlet. Lake Warren stood 100 feet above Lake Michigan and covered an area much larger than Lake Whittlesey, and it was lowered to approximately the present level when the retreat of the ice opened the Mackinac channel."

The opening of these outlets to the Grand River outlet probably added somewhat to the volume of water flowing thru the Chicago outlet, but this volume was not great enough to account entirely for the different stages of Glacial Lake Chicago. The low water stage during which the peat deposits were formed did not occur, probably, until after the Lake Whittlesey episode. It is possible that the low water stage was coincident with the Lake Wayne stage of the Ontario basin and that the subsequent elevation to the Lake Warren level, and the shifting of the outlet to the Grand River Valley, caused the rising of the Lake Chicago waters to the Calumet beach.

1918. ALDEN.[35]—In the discussion of the Quaternary geology of southeastern Wisconsin, this author devotes considerable space to the glacial stages of Lake Chicago, the shorelines—Glenwood, Calumet, Toleston—being described as in the papers of Leverett, Alden, Goldthwait, Salisbury, and Atwood, previously mentioned. The statements relative to Lake Chicago and those bearing on the postglacial and interglacial life considered in this volume are discussed in several places in the following pages.

III. SUMMARY

A study of the literature relating to the postglacial history of the Chicago Region shows that, while considerable information has been accumulated concerning the biota of the old lake basin, little or no systematic field work has

[34] Bull. Geol. Soc. Amer., XXVIII, p. 142, 1917.

[35] U. S. G. S., Prof. Paper 106, pp. 135, 136, 310-312, 326-339.

been carried on especially relating to this subject. The lack of our knowledge of this subject is probably due to the fact that the majority of the workers and students n this field have been geologists interested mainly in the stratigraphy and physiography of the area. That a systematic study of other parts of this and other regions would produce notable additions to our knowledge is evidenced by the results obtained by the writer from a systematic examination and study of the deposits exposed in the drainage ditches and other excavations made in t he Chicago Area, which are described in the following chapter.

CHAPTER II

DETAILED STUDY OF THE SEDIMENTARY DEPOSITS OF THE LAKE CHICAGO BASIN

I. General Statement

A careful study in great detail was made of the north shore channel during its construction, upwards of 63 distinct section stations being established. A larger number of intermediate check examinations were also made. These sections cover a distance of over eight miles, and pierce, for the most part, the bed of an ancient bay of Lake Chicago, known as Wilmette Bay. These studies have been supplemented by investigations in other parts of the region, in the aggregate covering a large part of the old bed of glacial Lake Chicago.

Measurements are in inches. Each section is divided into numbered strata, the stratum of each section being, for the most part, correlated in number with the same level of the other sections. The biological remains of each stratum are tabulated for all sections where evidences of life were found.

II. The North Shore Channel (Plate II)

The north shore channel of the Chicago drainage system extends about eight miles north of Foster Avenue, Bowmanville, uniting with Lake Michigan between North Evanston and Wilmette, just north of Gross Point. The channel is cut in the bed of a long bay which formed a part of glacial Lake Chicago. The sedimentary strata,—sand, gravel, and clay—rest on the till of the Late Wisconsin ice sheet. Between Foster Avenue and Devon Avenue, the ground moraine is undulating in cross section (see Plate III), differing strikingly from the region north of Devon Avenue, where the deposits rest upon a till plain which is comparatively level. This undulating ground moraine extends southward well toward the center of the city of Chicago. The greatest diversity of sedimentary deposits is found from Devon Avenue southward. A full discussion of the limits of the flooded area will be found in Chapter III.

In the present chapter the different sections are taken up in detail, beginning with the strata south of Foster Avenue and continuing northward to Lake Michigan. Sections from other parts of the city are also considered and compared with those of the north shore channel. Each station section is located its distance in feet from a well-known street, and its height above sea level (A.T.) and above Lake Michigan (A.L.M.) is given. The sedimentary strata are numbered from the boulder clay to the surface and the character of the deposit, as well as its thickness, is indicated in inches. The level of Lake Michigan is placed at approximately 580 feet above sea level (579.63 feet, vide map of Sanitary Commission of Chicago).

A. LAWRENCE AVENUE TO LINCOLN AVENUE

STATION I (Plates I, V)

200 feet south of Foster Avenue. Surface 587 feet A. T.; 7 feet A. L. M.

Strata	Deposit	Depth	Remarks
XI	Surface soil, silt and loam	19½	
X	Silt, somewhat peaty	12	
IX	Sand and pebbles	2	
VIII	Silt, peaty in spots	9	With pockets of shells.
VII	Sand	1	With shells.
VI	Silt	14	With pockets of shells.
V	Sand	1½	With *Anodonta* and gastropod shells.
IV	Silt	4	
III	Gravel and sand	19	With Unios.
II	Silt	2+	
I	Boulder clay?	+	Water level in canal.
	Total thickness	84+	

BIOLOGICAL REMAINS

Stratum III

Fusconaja undata
Crenodonta undulata
Quadrula pustulosa
" *lachrymosa*
Rotundaria tuberculata
Pleurobema coccineum magnalacustris
Elliptio crassidens
" *gibbosus*
Amygdalonajas elegans
Eurynia ellipsiformis
Lampsilis ventricosa

Stratum V

Anodonta species
Lampsilis luteola
Sphaerium striatinum
" *solidulum*
Campeloma integrum
Goniobasis livescens
Somatogyrus subglobosus

Stratum VI

Anodonta species
Pisidium compressum
" *noveboracense*
" *politum decorum*
" *splendidulum*
" *virginicum*
" *walkeri*
Sphaerium sulcatum
" *solidulum*
" *stamineum*
" *flavum*
" *striatinum*
Campeloma integrum
Valvata tricarinata
Amnicola limosa
" *emarginata*
Somatogyrus subglobosus
Goniobasis livescens
Physa warreniana
Planorbis antrosus
" *campanulatus*
" *trivolvis*
Galba reflexa
Lymnæa stagnalis appressa

Stratum VII

Sphaerium rhomboideum
" *sulcatum*
" *levissimum*
" *solidulum*
" *striatinum*
Pisidium affine
" *compressum*
" *kirklandi*
" *sargenti*
" *variabile*
Campeloma integrum
Campeloma subsolidum
Goniobasis livescens
Valvata tricarinata
Amnicola limosa
Planorbis antrosus
" *campanulatus*
" *parvus*
" *trivolvis*
Galba palustris
" *reflexa*

Stratum VIII

Pisidium compressum
" *noveboracense*
" *splendidulum*
" *variabile*
" *walkeri*
Sphaerium sulcatum
Amnicola limosa
Valvata tricarinata
Physa warreniana
Planorbis campanulatus
" *parvus*
" *antrosus*
Galba obrussa
" *reflexa*

STATION 2 (Plate VI)

100 feet south of Foster Avenue. Surface 585 feet A. T.; 5 feet A. L. M.

Strata	Deposit	Depth	Remarks
X-XI	Surface soil, silt and loam	30	
IX	Fine sand	½	
VIII	Silt, peaty in spots	7½	Shells in pockets.
VII	Fine sand	½	
VI	Silt	6	Shells in pockets.
V	Gravel and sand	1	
IV	Silt	1½	
III	Gravel and sand	14	Unio bed.
II	Silt	+	Water line in canal.
I	Boulder clay	+	
	Total thickness	61	

STATION 3

300 feet north of Foster Avenue. Surface 585 feet 8 in. A. T;. 5 feet 8 in. A. L. M.

Strata	Deposit	Depth	Remarks
VII	Surface soil, silt and loam...........	29	
VI	Sand...	½	
V	Peat and silt.................................	24	With shells and plants.
IV	Silt...	15	
III	Gravel and sand.............................	+	Water line of canal.
II	Silt...	+	
I	Boulder clay..................................	+	
	Total thickness....	68½	

BIOLOGICAL REMAINS

Stratum V

(Plants)

Potamogeton species.

(Animals)

Pisidium compressum lævigatum
" *splendidulum*
Amnicola limosa
Valvata tricarinata
Physa warreniana
Segmentina armigera
Ancylus parallelus

Planorbis antrosus
" *campanulatus*
" *exacuous*
" *parvus*
" *trivolvis*
Galba reflexa
Lymnaea stagnalis appressa
Vertebræ of a fish

STATION 4 (Plate I)

885 feet north of Foster avenue. 587 feet 7 in. A. T.; 5 feet 7 in. A. L. M.

Strata	Deposit	Depth	Remarks
XVI	Surface soil, silt and loam	17	
XV	Silt, sandy	10	
XIV	Sand, fine gray	$\frac{1}{32}$	
XIII	Silt	2½	Crushed shells.
XII	Potamogeton layer	$\frac{1}{16}$	
XI	Silt	42	In the lower part this stratum consist of layers of silt ½ or ¾ inches thick, separated by thin layers of sand. Life is rare in these layers.
X	Silt	4	
IX	Potamogeton layer	½	
VIII	Silt	3½	
VII	Chara layer, carbonaceous	1½	*Anodonta* and fish remains.
VI	Silt	14	Water level in canal.
V	Sand	19	Unio bed.
IV	Silt, peaty	8+	
III	Silt	+	
II	Sand end gravel	+	
I	Boulder clay	+	
	Total thickness	122	

BIOLOGICAL REMAINS

Stratum V

Elliptio crassidens
" *gibbosus*
Rotundaria tuberculata
Crenodonta undulata
" *peruviana*
Pleurobema coccineum magnalacustris

Stratum VII

(Plants)

Picea mariana
Quercus sp.
Chara sp.
Carex sp.

Animals (Invertebrates)

Elliptio gibbosus
Anodonta grandis footiana
Sphaerium sulcatum
" *flavum*
Pisidium virginicum
" *compressum*
" *variabile*
" *politum*
Amnicola limosa
" *lustrica*
" *emarginata*
Somatogyrus subglobosus
Physa warreniana
" *integra*
Planorbis antrosus
" *campanulatus*

Pisidium pauperculum
" *splendidulum*
Musculium secure
Campeloma integrum
Goniobasis livescens
Valvata tricarinata
Planorbis parvus
" *trivolvis*
Galba palustris
" *reflexa*
Lymnaea stagnalis appressa
Ancylus parallelus

(Vertebrates)

Amia calva
Either a silurid or a cyprinoid.
Lepomis species

Stratum IX

Potamogeton species
Najas species
Hypnum species

Stratum X

(Plants)

Potamogeton species
Najas species

(Animals)

Sphaerium striatinum
Pisidium compressum
" *variabile*
" *scutellatum*
Campeloma integrum
Valvata tricarinata
Amnicola emarginata
" *limosa*
Somatogyrus subglobosus
Physa integra
Planorbis antrosus
" *deflectus*
" *parvus*

Stratum XI

(Plants)

Potamogeton species
Nymphaea advena
Carex sp.
Scirpus sp.
Najas species
Typha latifolia

Animals (Invertebrates)

Sphaerium sulcatum
" *striatinum*
Pisidium compressum
" *affine*
" *noveboracense*
Campeloma integrum
Amnicola limosa
Valvata tricarinata
Planorbis antrosus
" *trivolvis*
Galba reflexa

Stratum XII

Potamogeton species

Stratum XIII

(Plants)

Potamogeton species

(Animals)

Sphaerium sulcatum
" *striatinum*
Pisidium compressum
" *variabile*
Amnicola limosa
Valvata tricarinata
Physa integra
Planorbis antrosus
" *campanulatus*

STATION 5

950 feet north of Foster Avenue. 590 feet A. T. west side of canal.

Strata	Deposit	Depth	Remarks
II	Sandy loam and silt	40	No life.
I	Boulder clay	+	

STATION 6

1060 feet north of Foster Avenue. 590 feet A. T. west side of canal.

Strata	Deposit	Depth	Remarks
II	Yellow sand	17	No life.
I	Boulder clay	+	

STATION 7

1170 feet north of Foster Avenue. 590 feet A. T. west side of canal.

Strata	Deposit	Depth	Remarks
II	Yellow sand	36	
I	Boulder clay	+	Pockets of gravel 42 inches below the surface.

STATION 8

1210 feet north of Foster Avenue. 590 feet A. T. west side of canal.

Strata	Deposit	Depth	Remarks
IX	Yellow sand, oxidized	26	
VIII	Silt, oxidized	15	
VII	Silt, peaty	7	Shells and plants.
VI	Peat, with thin layers of silt	11	Shells and plants.
V	Silt	37	With leaves of *Quercus*, shells and pieces of wood.
IV	Silt	10	Unio bed.
III	Silt, very fine	16	With pieces of wood.
II	Gravel	6	
I	Boulder clay	+	
	Total thickness	128	

STATIONS 9 AND 10 (Plates I, VII)

1402 and 1420 feet north of Foster Avenue. 590 feet A. T.

Strata	Deposit	Depth		Remarks
		9	10	
XIV	Silt and loam, black	5	5	
XIII	Silt, yellow	9	9	
XII	Silt, oxidized	23	23	Beds of shells every 2-3 inches.
XI	Sand	1/8	1/8	
X	Silt	3	3	With plants and shells.
IX	Silt	56	56	With plant stems and few shells.
VIII	Silt and fine sand	14	14	Unio bed; few pebbles; wood.
VII	Silt, peaty	5	5	With plants, shells, wood.
VI	Sand, coarse	1	4	With shells.
V	Silt	1½		With pieces of wood.
IV	Sand, coarse	1		
III	Silt	1		
II	Gravel	6	4	
I	Boulder clay	10+	10+	
	Total thickness	135⅝	133⅛	

BIOLOGICAL REMAINS

Stratum VII

(Plants)

Quercus species
Picea mariana
Populus balsamifera
Carex sp.

(Animals)

Sphaerium sulcatum
" *acuminatum*
" *solidulum*
" *flavum*
Pisidium affine
" *variabile*
" species
Valvata tricarinata
Amnicola limosa
" *lustrica*
Goniobasis livescens
Campeloma integrum
Physa warreniana
Ancylus fuscus
" *parallelus*
Segmentina armigera
Planorbis antrosus
" *campanulatus*
" *deflectus*
" *exacuous*
" *parvus*
" *trivolvis*
Galba reflexa
Lymnaea stagnalis appressa

Stratum VIII

Fusconaja undata
Crenodonta undulata
Amygdalonajas elegans
Proptera alata

Crenodonta peruviana
Quadrula pustulosa
" *lachrymosa*
Rotundaria tuberculata
Pleurobema coccineum magnalacustris
Elliptio crassidens
" *gibbosus*
Symphynota costata
Obliquaria reflexa
Lampsilis luteola
" *ventricosa*
Pisidium compressum
" *scutellatum*
" *virginicum*
Campeloma integrum
" *subsolidum*
Goniobasis livescens
Amnicola letsoni

Stratum X
(Plants)

Quercus species

(Animals)

Sphaerium sulcatum
" *striatinum*
Pisidium affine
" *abditum*
" *compressum*
" *politum*
" *scutellatum*
" *variabile*
Campeloma subsolidum
Valvata tricarinata
Amnicola emarginata
Amnicola limosa
" *lustrica*
Physa warreniana
Ancylus fuscus
Planorbis antrosus
" *campanulatus*
" *deflectus*
" *parvus*
" *trivolvis*
Galba palustris
Lymnaea stagnalis appressa

STATION 11 (Plate I)

1805 feet north of Foster Avenue. Surface 590 feet A.T.; 10 feet A. L. M.

Strata	Deposit	Depth	Remarks
II	Sand, yellow	12	No life.
I	Boulder clay	116	
	Total thickness	128	

STATIONS 12 & 13 (Plate I)

1935-1950 feet north of Foster Avenue. Surface 590 feet A.T; 10 feet A.L.M.

Strata	Deposit	Depth 12	Depth 13	Remarks
XIII	Silt and loam	18	18	
XII	Silt	14	14	
XI	Sand	2½	2½	
X	Silt	14½	14½	
IX	Sand	2	2	
VIII	Silt	13	13	Thin beds of sand ¾ and 1 inch apart.
VII	Silt	10½	10½	With Unios.
VI	Sand and gravel	9	4½	With Unios on surface.
V	Silt	3½	21	With wood.
IV	Sand and gravel	2½		
III	Silt	6		With wood.
II	Sand	2	2	
I	Boulder clay	34+	26+	
	Total thickness	131½	131	

STATION 14

1985 feet north of Foster Avenue. Surface 590 feet A.T; 10 feet A.L.M.

Strata	Deposit	Depth	Remarks
XIV	Silt and loam	31	Black, clayey.
XIII	Silt	½	With shells.
XII	Silt	20	Without life.
XI	Silt	5	With sandy layers.
X	Silt	2	With shells.
IX	Silt	7½	Without life.
VIII	Sand	½	
VII	Silt	2½	
VI	Sand	½	
V	Silt	8	
IV	Gravel and sand	14	With Unios
III	Silt	10	With wood.
II	Sand	3	
I	Boulder clay	24+	
	Total thickness	128½	

STATION 15 (Plates I, VIII)

2150 feet north of Foster Avenue. Surface 590 feet A.T; 10 feet A.L.M.

Strata	Deposit	Depth	Remarks
IV	Silt and loam	31	
III	Silt	13	
II	Gravel and sand	15	With Unios.
I	Boulder clay	66+	
	Total thickness	125	

STATION 16 (Plates I, IX)

2200 feet north of Foster Avenue. Surface 590 feet A.T; 10 feet A.L.M.

Strata	Deposit	Depth	Remarks
XII	Silt and loam	19	Few shells in pockets in lower part.
XI	Silt	9½	With crayfish holes.
X	Peat	5=	
IX	Silt	7=	Mollusks, leaves, twigs; crayfish burrow.
VIII	Marl bed	4½	Solid bed of shells.
VII	Peat bed	½	With twigs and sticks.
VI	Silt	9	With shells.
V	Silt	13	
IV	Gravel and sand	15	With Unios.
III	Silt	18	With wood.
II	Sand	3½	
I	Boulder clay	27+	
	Total thickness	132½	

BIOLOGICAL REMAINS

Stratum IV

Fusconaja undata
Crenodonta peruviana
Quadrula pustulosa
" *lachrymosa*
Rotundaria tuberculata
Pleurobema coccineum magnalacustris
Elliptio crassidens
" *gibbosus*
Sphaerium rhomboideum
Pisidium affine
" *compressum*
" *pauperculum*
" *politum*
" *splendidulum*
" *walkeri*
" *variabile*
Campeloma integrum
Goniobasis livescens

Stratum VIII

Sphaerium sulcatum	*Valvata tricarinata*
" *rhomboideum*	*Physa warreniana*
" *solidulum*	" *integra*
Pisidium compressum	*Planorbis antrosus*
" *splendidulum*	" *campanulatus*
" *variabile*	" *deflectus*
" *virginicum*	" *parvus*
Campeloma integrum	" *trivolvis*
Amnicola limosa	*Galba reflexa*
" *lustrica*	*Lymnaea stagnalis appressa*

STATION 17 (Plate X)

2250 feet north of Foster Avenue. Surface 590 feet A.T.; 10 feet A.L.M.

Strata	Deposit	Depth	Remarks
A. XV	Silt and loam	20	
B. XIV	Peat	6	
C. XIII	Silt	10¼	Some bog ore.
XII	Sand	⅛	
D. XI	Silt	6½	Some bog ore.
E. X	Peat	1½	Few shells.
F. IX	Silt	20	
G. VIII	Silt	7	
VII	Sand	⅛	With shells.
H. VI	Silt	2½	
K. V	Silt	15	Layers of sand with shells.
L. IV	Gravel and sand	11½	With Unios.
M. III	Silt	18	With wood, bog ore, shells.
II	Sand	2	
I	Boulder clay	10	
	Total thickness	130½	

STATION 18

2345 feet north of Foster Avenue. Surface 590 feet A.T.; 10 feet A.L.M.

Strata	Deposit	Depth	Remarks
XVII	Silt and loam	23	
XVI	Peat	6	
XV	Silt	12	With few shells.
XIV	Peat	½	With few shells.
XIII	Silt	21	Pockets of shells.
XII	Sand	1	With pebbles.
XI	Silt	5½	
X	Fine sand	2	With shells.
IX	Silt	4	
VIII	Fine sand	3	With shells.
VII	Silt	5	
VI	Sand	¼	With shells.
V	Silt	5	
IV	Gravel and sand	12	With Unios.
III	Silt	18	With shells, logs, leaves.
II	Sand	2	
I	Boulder clay	10	
	Total thickness	130¼	

BIOLOGICAL REMAINS

Stratum IV

Fusconaja undata
Crenodonta peruviana
" *undulata*
Quadrula pustulosa
Rotundaria tuberculata
Pleurobema coccineum magnalacustris
Elliptio crassidens
" *gibbosus*
Sphaerium sulcatum
" *levissimum*
Campeloma integrum
Goniobasis livescens

Stratum VI

Pisidium compressum
" *virginicum*
Quadrula pustulosa
Rotundaria tuberculata
Lampsilis luteola
Goniobasis livescens
Campeloma subsolidum

Stratum VIII

Lampsilis luteola
Sphaerium striatinum
Pisidium affine
" *variabile*
Goniobasis livescens
Campeloma integrum
" *subsolidum*
Galba reflexa
Planorbis parvus

Stratum X

Crenodonta peruviana	*Physa integra*
Goniobasis livescens	

Stratum XII

Valvata tricarinata	*Planorbis antrosus*

Stratum XIII

Sphaerium rhomboideum	*Physa integra*
Pisidium compressum	" *warreniana*
" *variabile*	*Planorbis deflectus*
" *walkeri*	" *parvus*
" *politum*	" *trivolvis*
" *noveboracense*	" *antrosus*
Valvata tricarinata	" *campanulatus*
Amnicola limosa	*Galba palustris*
Campeloma integrum	" *reflexa*
	Lymnaea stagnalis appressa

STATION 19 (Plates I, XI)

2390 feet north of Foster Avenue. Surface 590 feet A.T.; 10 feet A.L.M.

Strata		Deposit	Depth	Remarks
A.	XVII	Silt and loam	23	
B.	XVI	Peat	3½	Vegetation in layers.
C.	XV	Silt	7	Bog ore and twigs.
D.	XIV	Sand	1½	With shells.
E.	XIII	Silt	9	Very thin beds of sand in silt.
	XII	Sand	$\frac{1}{16}$	
	XI	Silt	12½	
	X	Sand	$\frac{1}{16}$	
	IX	Silt	5	
	VIII	Sand	$\frac{1}{16}$	
	VII	Silt	3½	
	VI	Sand	$\frac{1}{16}$	
	V	Silt	3	
F.	IV	Sand and gravel	3½	Unio bed.
G.	III	Silt	18	With bog ore and wood.
	II	Sand and gravel	5	
H.	I	Boulder clay	34	
		Total thickness	128¾	

STATION 20

2500 feet north of Foster Avenue. Surface 590 feet A. T.; 10 feet A. L. M.

Strata	Deposit	Depth	Remarks
A. V	Silt and loam	22	
B. IV	Silt	17½	With bog ore.
C. III	Gravel and sand	4	With Unios.
D. II	Silt	9	With bog ore. Thickness varies from 9 to 40 inches on slope of ground moraine.
E. I	Boulder clay	78	
	Total thickness	130½	

STATION 21 (Plates I, XII)

2630 feet north of Foster Avenue. Surface 590 feet A. T.; 10 feet A. L. M.

Strata	Deposit	Depth	Remarks
VIII	Silt and loam	21	
A. VII	Silt	17	
VI	Sand	$\frac{1}{16}$	
B. V	Silt	30	
C. IV	Sand and gravel	17	With Unios.
D. III	Silt	15	With wood.
II	Sand	4	
I	Boulder clay	25	
	Total thickness	$129\frac{1}{16}$	

STATION 22 (Plate I)

2690 feet north of Foster Avenue. Surface 590 feet A. T.; 10 feet A. L. M.

Strata	Deposit	Depth	Remarks
XVI	Silt and loam	21	
XV	Sand	12	
XIV	Sand	½	With shells.
XIII	Silt	13	
XII	Sand	½	With shells.
XI	Silt	3½	
X	Sand	½	With shells.
IX	Silt	16½	
VIII	Sand	½	With shells.
VII	Silt	5	Humerus of duck.
VI	Sand	½	With shells.
V	Silt	4	
IV	Sand and gravel	2	With Unios.
III	Silt	12	With wood.
II	Sand and gravel	12	
I	Boulder clay	25	
	Total thickness	128½	

BIOLOGICAL REMAINS

Stratum IV

Crenodonta peruviana
" *undulata*
Quadrula pustulosa
" *lachrymosa*
Rotundaria tuberculata
Pleurobema coccineum magnalacustris
Elliptio crassidens
" *gibbosus*
Obliquaria reflexa
Amygdalonajas elegans
Lampsilis ventricosa
Sphaerium striatinum
" *flavum*
Pisidium compressum
" *variabile*
" *virginicum*
Campeloma integrum
Goniobasis livescens
Amnicola limosa

Stratum VI

Fusconaja undata
Quadrula pustulosa
Elliptio gibbosus
Lampsilis luteola

Stratum VII

Mergus serrator (humerus)

Stratum VIII

Crenodonta undulata
Quadrula pustulosa
" *lachrymosa*
Elliptio gibbosus
Amygdalonajas elegans
Sphaerium flavum

Rotundaria tuberculata
Pleurobema coccineum magnalacustris
Elliptio crassidens
Campeloma integrum
Goniobasis livescens
Amnicola limosa

Stratum X

Quadrula pustulosa
Campeloma integrum

Stratum XII

Anodonta species
Sphaerium flavum
Pisidium politum
Goniobasis livescens
Amnicola emarginata
Planorbis parvus

Stratum XIV

Sphaerium stamineum
" *solidulum*
Musculium transversum
Amnicola limosa porata
Physa gyrina
Planorbis trivolvis
Galba palustris

STATIONS 23 TO 26

2750, 2860, 3200, 3240 feet north of Foster Avenue. Surface 590 feet A. T.; 10 feet A.L.M

Strata	Deposit	Depth				Remarks
		23	24	25	26	
VII	Silt	54	72	50	53	Interstratified with sand.
VI	Sand	¼	¼	¼	¼	
V	Silt	6	6	4	5	
IV	Gravel and sand	2	11	2	9	With Unios.
III	Silt, oxidized	17	....	25	....	
II	Gravel	7	....	15	....	
I	Boulder clay	44	41	34	63	
	Total thickness	130¼	130¼	130¼	130¼	

STATION 27 (Plate XIII)

3750 feet north of Foster Avenue. Surface 590 feet A.T.; 10 feet A.L.M.

Strata	Deposit	Depth	Remarks
A. IV	Silt	60	Interstratified with sand.
B. III	Sand and gravel	4	With Unios.
C. II	Silt	22	With wood, leaves and shells.
I	Boulder clay	36	
	Total thickness	122	

BIOLOGICAL REMAINS

Stratum II

Plants

Quercus species

Animals

Anodonta grandis
Pisidium affine
" *compressum*
" *variabile*
Sphaerium sulcatum
Goniobasis livescens
Campeloma integrum obesum
Amnicola limosa
" *lustrica*
Valvata tricarinata
Physa warreniana
" *gyrina*
Planorbis antrosus
" *campanulatus*
" *deflectus*
" *trivolvis*
Galba palustris
Lymnaea stagnalis appressa

STATION 28 (Plates I, XIV)

3585 feet north of Foster Avenue. Surface 590 feet A.T.; 10 A.L.M.

Strata	Deposit	Depth	Remarks
A. V	Silt	66	Interstratified with sand.
B. IV	Sand and gravel	4	With Unios.
C. III	Silt	23	With wood, oak, shells.
D. II	Sand and gravel	4	
I	Boulder clay	34+	
	Total thickness	131	

BIOLOGICAL REMAINS

Stratum III

Plants

Potamogeton species
Quercus species

Animals

Anodonta grandis
Pisidium affine
" *compressum*
" *variabile*
Sphaerium sulcatum
Goniobasis livescens
Campeloma integrum obesum
Amnicola limosa
" *lustrica*
Valvata tricarinata
Physa warreniana
" *gyrina*
Planorbis antrosus
" *campanulatus*
" *deflectus*
" *trivolvis*
Galba palustris
Lymnaea stagnalis appressa

Stratum IV

Crenodonta undulata
" *peruviana*
Amygdalonajas elegans
Sphaerium striatinum

Quadrula pustulosa
Rotundaria tuberculata
Elliptio crassidens
Campeloma integrum
Goniobasis livescens
Amnicola limosa

STATION 29 (Plates I, XV)

3625 feet north of Foster Avenue. Surface 590 feet A.T.; 10 feet A.L.M.

Strata	Deposit	Depth	Remarks
A. VIII	Silt and loam	18	
B. VII	Silt	23	
C. VI	Silt	39	Sand and shells intermixed.
D. V	Sand and gravel	4	With Unios.
E. IV	Sand	1	
F. III	Silt and peat	7½	Carbonaceous, with peat, wood, and a few shells.
G. II	Sand	5	
H. I	Boulder clay	32+	
	Total thickness	129½	

STATIONS 30 AND 31 (Plate XVI)

3675 and 3750 feet north of Foster Avenue. Surface 590 feet A.T.; 10 feet A.L.M.

Strata	Deposit	Depth		Remarks
		30	31	
VII	Silt and loam	21	21	
VI	Silt	23	23	
V	Silt	39	39	
IV	Sand and gravel	4½	4½	With Unios.
III	Silt	4	8½	With logs, leaves, peat.
II	Sand and gravel	5	7½	Gravel, very irregular in thickness.
I	Boulder clay	36	31	
	Total thickness	132½	132½	

STATION 32 (Plate I)

4100 feet north of Foster Avenue. Surface 595 feet A.T.; 15 feet A.L.M.

Strata	Deposit	Depth	Remarks
II	Sandy loam	12	No life.
I	Boulder clay	168	
	Total thickness	180	

B. LINCOLN AVENUE TO DEVON AVENUE

STATION 33 (Plates I, XVII)

500 feet south of Devon Avenue. 595 feet A.T.; 15 feet A.L.M.

Strata	Deposit	Depth	Remarks
XVII	Silt and loam	20	
XVI	Silt	32	
A. XV	Peat	38	Interstratified with thin beds of sand.
B. XIV	Occasional sand pockets		Rarely as thick as 12 inches.
XIII	Gray sand		Very thin layer.
C. XII	Silt	6	Anodonta and wood on top of this layer.
D. XI	Sand, gray	4	With wood and Sphaerium.
E. X	Silt	4	
F. IX	Sand, gray	2½	
G. VIII	Silt	2½	
H. VII	Silt and sand, mixed	11	
K. VI	Wood	1	Solid layer.
V	Sand and gravel	6	
IV	Wood, with sand	1½	With spruce cones.
III	Sand	4	With shells, wood, and spruce cones.
II	Sand with some gravel	4	
I	Boulder clay	44+	
	Total thickness	180	

BIOLOGICAL REMAINS

Stratum III

Plants

Picea canadensis

Animals

Proptera alata
Anodonta grandis
Sphaerium stamineum
" *striatinum*
Pisidium species

Valvata tricarinata
Amnicola limosa
" *emarginata*

Stratum IV

Picea canadensis

Stratum VI

Picea canadensis

Stratum VIII

Abies balsamea
Larix laricina
Thuja occidentalis
Picea canadensis
Picea mariana

Cast of Unionid

Stratum IX

Picea canadensis

Sphaerium stamineum

Stratum X

Picea canadensis

Sphaerium striatinum
" *stamineum wisconsinensis*
" *solidulum*

Stratum XI

Picea canadensis

Anodonta grandis
Sphaerium stamineum wisconsinensis
" *striatinum*

Stratum XII

Sphaerium stamineum wisconsinensis
" *solidulum*

Anodonta grandis

Stratum XV

Sphaerium flavum

STATIONS 34 AND 35

530 and 495 feet south of Devon Avenue. Surface 595 feet A.T.; 15 feet A.L.M.

Strata	Deposit	Depth		Remarks
		34	35	
VII	Sandy soil (loam)	21	20	
VII	Sand, yellow	28	39	With pebbles and a few boulders.
V	Peat, interstratified with sand	78	67	Peat layers ⅛ to ½ inches thick; pieces of wood.
IV	Silt	8	8	
III	Sand	14	14	With wood.
II	Shingle	3	3	Varies from 2-3 inches in thickness.
I	Boulder clay	28	28	
	Total thickness	180	179	

STATIONS 36 AND 37 (Plate XVIII)

505 and 490 feet south of Devon Avenue. Surface 595 feet A. T.; 15 feet A.L.M.

Strata	Deposit	Depth		Remarks
		36	37	
XIV	Sandy soil (loam)	20	20A	
XIII	Silt	32	32B	With plant remains.
XII	Peat	32	32C	
XI	Silt	8	6½D	
X	Gray sand	3¾	2E	With wood.
IX	Silt	1½	1F	
VIII	Gray sand	¾	1	With wood.
VII	Silt	1¼	3	
VI	Gray sand	1½	2½G	
V	Silt	7	1H	With shells.
IV	Silt, interstratified with sand	29	29½K	With wood.
III	Silt and fine sand	6	2	With bivalve shells.
II	Gravel and coarse sand	4	8L	
I	Boulder clay	34	40	
	Total thickness	180¾	180½	

BIOLOGICAL REMAINS

Station 36

Stratum III

Plants

Picea canadensis

Animals

Lampsilis luteola
Anodonta grandis footiana
Sphaerium stamineum wisconsinensis
" *striatinum*
" *acuminatum*
Pisidium idahoense
Amnicola limosa
" *emarginata*

Station 37

Stratum between IV–V

Anodonta grandis footiana
Sphaerium striatinum
" *acuminatum*

Stratum V

Picea canadensis

STATION 37 A (Plate XIX)

400 feet south of Devon Avenue. Surface 595 feet A. T.; 15 feet A.L.M.

Strata	Deposit	Depth	Remarks
III	Sandy soil (loam)	20	
II	Sand and gravel	18	Varies in thickness.
I	Boulder clay	142	
	Total thickness	180	

C. DEVON AVENUE TO CHURCH STREET

STATION 38

1000 feet north of Devon Avenue. Surface 595 feet A.T.; 15 feet A.L.M.

Strata	Deposit	Depth	Remarks
III	Sandy loam	33	3 feet south this deposit is 36 inches thick.
II	Coarse gravel and shingle	6	
I	Boulder clay	141	Apparently water laid in upper portion. 75-100 feet south all is in boulder clay.
	Total thickness	180	

STATION 39 (Plate I)

500 feet south of Touhy Avenue. Surface 595 feet A.T.; 15 feet A.L.M.

Strata	Deposit	Depth	Remarks
IV	Sand loam	26	
III	Gravel	4	
II	Water laid clay	81	Upper 40 inches without boulders and with roots of plants; lower 40 inches with few boulders.
I	Boulder clay	69	
	Total thickness	180	

Pocket in stratum II

	Deposit	Depth	Remarks
	Sand	14	
	Gravel and coarse sand	15	These pockets are of greater or less size and occur about midway of stratum II.
	Clay, interstratified with sand	7	
	Coarse sand and gravel	2	
	Total thickness	38	

STATION 40

Touhy Avenue, north of bridge. Surface 595 feet A.T.; 15 feet A.L.M.

Strata	Deposit	Depth	Remarks
IV	Silt and loam	36	With shells.
III	Gravel	3½	
II	Water laid clay	72	
I	Boulder clay	108	
	Total thickness	219½	

STATIONS 41 AND 42

2000 feet north of Touhy Avenue and 200 feet north of Oakton Avenue Surface 595 feet A.T.; 15 feet A.L.M.

Strata	Deposit	Depth 41	Depth 42	Remarks
VII	Silt and loam	39	45	With shells.
VI	Gravels, pebbles, and sand	2	4	
V	Clay	20	21	With plant roots.
IV	Laminated clay		30	
III	Blue clay		18	
II	Laminated clay	....	4	
I	Boulder clay	156	96	
	Total thickness	217	218	

BIOLOGICAL REMAINS (Station 42)

Stratum VII

Sphaerium stamineum
" *emarginatum*
Physa gyrina
Segmentina armigera
Planorbis parvus
Planorbis trivolvis
Galba caperata
" *reflexa*
Succinea retusa
Cambarus blandingi acutus

STATION 43 (Plates I, XX)

1000 feet north of Oakton Avenue. Surface 595 feet A.T.; 15 feet A.L.M.

Strata	Deposit	Depth	Remarks
VIII	Silt and loam	36	With shells.
VII	Sand and gravel	5	
VI	Laminated clay interstratified with layers of very thin sand	30	Rootlets in upper 10 or 15 inches.
V	Clay	36	With boulders.
IV	Laminated clay	4	
III	Blue clay	16	
II	Sandy Clay	1	
I	Boulder clay	96	
	Total thickness	224	

STATION 44 (Plate XXI)

500 feet south of Dempster Street. Surface 595 feet A.T.; 15 feet A.L.M.

Strata	Deposit	Depth	Remarks
VI	Silt and loam	30	With shells.
V	Sand and gravel; few boulders	5	This deposit lies from 30 to 40 inches below the surface, and varies from 2 to 6 inches in thickness.
IV	Blue clay	36	With rootlets.
III	Brownish-yellow sandy clay	10	See rule in photograph.
II	Laminated blue clay	60	
I	Boulder clay	84	
	Total thickness	225	

STATION 45 (Plate XXII)

200 feet south of Dempster Street. Surface 595 feet A.T.; 15 feet A.L.M.

Strata	Deposit	Depth	Remarks
V	Silt and loam	33	Shells begin 12 inches below the surface.
IV	Sand and gravel	2	In places nearby 3 inches.
III	Blue clay	30	With rootlets.
II	Laminated clay	30	
I	Boulder clay	132	
	Total thickness	227	

BIOLOGICAL REMAINS

Stratum V

Musculium truncatum
Pisidium affine
Physa gyrina
Planorbis trivolvis
Segmentina armigera
Galba caperata
" *reflexa*
Succinea retusa
" *avara*

STATIONS 46 AND 47 (Plate I)

100 feet south of Dempster Street; 200 feet north of Dempster street. Surface 597 feet A.T.; 17 feet A.L.M.

Strata	Deposit	Depth 46	Depth 47	Remarks
IX	Silt and loam	23	23	With shells.
VIII	Sand and gravel	20	12	
VII	Blue clay	26	40	With rootlets.
VI	Yellow sand	¼	½	Very fine.
V	Blue clay	1	1	
IV	Yellow sand	¼	½	Very fine.
III	Blue clay	1½	3	
II	Yellow sand	¼	½	Very fine.
I	Boulder clay	144	144	
	Total thickness	216¼	224½	

BIOLOGICAL REMAINS

Same as section 45

STATION 48 (Plate XXIII)

800 feet south of Church Street. Surface 597 feet A.T.; 17 feet A.L.M.

Strata	Deposit	Depth	Remarks
VI	Silt and loam	33	Shells rare.
V	Sand and gravel	3	This stratum thins out 200 feet south of Church Street.
IV	Silt	3	
III	Blue clay	4½	
II	Coarse sand and gravel	6½	
I	Boulder clay	180	
	Total thickness	230	

D. CHURCH STREET TO CENTRAL AVENUE

STATION 49 (Plate XXIV)

300 feet north of Church Street. Surface 597 feet A.T.; 17 feet A.L.M.

Strata	Deposit	Depth	Remarks
VI	Silt and loam	12	No mollusks.
V	Blue clay	60	With rootlets.
IV	Yellow sand	1	
III	Sandy clay, with pockets of sand	36	
II	Yellow sandy clay	4	
I	Boulder clay	144	
	Total thickness	257	

STATIONS 50 TO 53

1200, 2000, 3000, 4000 feet north of Church Street. Surface 597-598 feet A.T.

Strata	Deposit	Depth				Remarks
		50	51	52	53	
V	Black loam	12	12	12	12	
IV	Blue clay	48	48	48	48	With rootlets.
III	Sand	¼	¼	¼	¼	
II	Laminated clay	48	48	48	48	With pockets of sand.
I	Boulder clay	144	144	156	168	
	Total thickness	252¼	252¼	264¼	276¼	

STATION 54 (Plate I)

650 feet south of Northwestern Railroad bridge. Surface 598 feet A.T.; 18 feet A.L.M.

Strata	Deposit	Depth	Remarks
X	Silt and loam	24	
IX	Gravel and coarse sand	4	
VIII	Laminated clay	44	With rootlets.
VII	Sand	1	Some gravel.
VI	Clay	40	
V	Sand	½	
IV	Clay	12½	
III	Sand	⅛	
II	Clay	12	
I	Boulder clay	108	
	Total thickness	246⅛	

STATION 55

500 feet north of Northwestern Railroad bridge. Surface 599 feet A.T.; 19 feet A.L.M.

Strata	Deposit	Depth	Remarks
V	Black sandy soil	24	This deposit begins 100 feet north of bridge.
IV	Yellow sand	16	
III	Gravel	I	
II	Clay	40	With rootlets.
I	Boulder clay	156	
	Total thickness	237	

STATIONS 56-58 (Plate I)

300 feet south of Central Avenue; Central Avenue; 300 feet north of Central Avenue. Surface 600 feet A.T.; 20 feet A.L.M.

Strata	Deposit	Depth			Remarks
		56	57	58	
V	Black top soil, sandy	8	....	....	
IV	Yellow sand..........................	20	42	13	Sand at surface in 58
III	Coarse sand and gravel........	14½	....	17	
II	Clay..	42	40	44	With rootlets.
I	Boulder clay..........................	156	156	168	
	Total thickness....	240½	238	242	

E. CENTRAL AVENUE TO THE LAKE

STATION 59

400-600 feet north of Milwaukee Railroad bridge. Surface 600 feet A.T.; 20 feet A.L.M.

Strata	Deposit	Depth		Remarks
		400	600	
IV	Sand..	7	30	
III	Gravel......................................	17	12	
II	Clay..	49	42	With rootlets.
I	Boulder clay............................	168	156	
	Total thickness......	241	240	

STATION 60 (Plate I)

1500 feet south of the Lake shore. Surface 610 feet A.T.; 30 feet A.L.M.

Strata	Deposit	Depth	Remarks
VII	Black sand	9	
VI	Black sand and gravel	85	More or less stratified in lower part.
V	Gray sand	15	Several layers of fine wood.
IV	Peat and wood	9	
III	Gravel and sand	5½	
II	Clay	14	With rootlets.
I	Boulder clay	223	
	Total thickness	360½	

STATION 61 (Plate I)

North edge of beach ridge (station 60). Surface 605 feet A.T.; 25 feet A.L.M.

Strata	Deposit	Depth	Remarks
IV	Beach sand and gravel	34	
III	Carbonaceous sand with wood	28	Gravel in lower part.
II	Clay	25	With rootlets.
I	Boulder clay	156	
	Total thickness	243	

STATION 62 (Plate I)

500 feet south of Lake Michigan. Surface 602 A.T.; 22 feet A.L.M.

Strata	Deposit	Depth	Remarks
XII	Black sand	8	
XI	Yellow sand	2	1¼ inches in some places.
X	Clay	2	
IX	Yellow sand	2½	
VIII	Sand with wood	2¼	1½ inches in some places.
VII	Yellow sand	2	
VI	Sandy clay	2	
V	Wood	1	
IV	Sand	2	
III	Gravel	2	1 inch in some places.
II	Clay	25	With rootlets in upper part.
I	Boulder clay	192	
	Total thickness	242¾	

STATION 63 (Plate I)

Gross Point, Lake Michigan. Surface 600 feet A.T.; 20 feet A.L.M.

Strata	Deposit	Depth	Remarks
XII	Black sand	17	Beach deposit.
XI	Yellow sand	17	" "
X	Peat and wood	¼	
IX	Yellow sand	1½	
VIII	Peat and wood	1¾	
VII	Yellow sand	2	
VI	Wood	¼	
V	Yellow sand	1	
IV	Sandy clay	3¼	2 inches in some places.
III	Wood	¼	
II	Clay	4	3 inches in some places.
I	Boulder clay	192	
	Total thickness	240¼	

BIOLOGICAL REMAINS

Strata III, VI, VIII, X

Coniferous wood (*Picea canadensis?*)
Oak (*Quercus* species)

III. General Records from the Chicago Basin

A. In the Vicinity of Riverside

Ogden Ditch at Austin Avenue

Surface 590 feet A.T.; 10 feet A.L.M.

Strata	Deposit	Depth	Remarks
V	Silt and loam	24	
IV	Silt	24	Unios in upper part.
III	Peat	12	
II	Marl bed	12	With shells.
I	Clay	+	
	Total thickness	72	

BIOLOGICAL REMAINS

Stratum II

Musculium secure
" *truncatum*
Pisidium medianum
" *tenuissimum*
Amnicola limosa
" *lustrica*
Valvata tricarinata unicarinata
Physa warreniana
" *walkeri*
Planorbis antrosus
" *campanulatus*
" *parvus*
Galba obrussa decampi

Stratum IV

Pleurobema coccineum magnalacustris
Fusconaja rubiginosa
Rotundaria tuberculata
Elliptio gibbosus
Eurynia recta

Near Oak Park and Ogden Avenues

Surface 605 feet A.T.; 25 feet A.L.M.

Strata	Deposit	Depth	Remarks
VI	Black sandy soil	22	
V	Yellow sand	11	
IV	Silt	10	Oxidized.
III	Gray sand	6	With pebbles and shingle.
II	Clay	9	
I	Boulder clay	20+	
	Total thickness	78	

B. SOUTH OF JACKSON PARK

It is reported[1] that a ledge of rock, 300 or 400 feet in width, extends a short distance west of Yates Avenue, north of 75th Street. The rock here does not show at the surface, but on Kingston Avenue, about one-half block north of 75th Street, there is a small outcropping.

On the corner of 75th Street and Jeffery Avenue, about five feet beneath the surface, a sand and gravel deposit occurs, in which the following mollusks were found by Mr. Ira Meyers, of the Francis Parker School, Chicago:

Alasmidonta calceola
Sphaerium striatinum
Pisidium virginicum
" *compressum confertum?*
" *superius*
" (resembling *mainense*, but apparently distinct)
Galba catascopium
Physa integra
Valvata bicarinata perdepressa
Goniobasis livescens
Amnicola lustrica
" *emarginata*
" *letsoni*
Somatogyrus integer

The sand and shells were evidently washed behind the submerged limestone barrier which outcrops on Kingston Avenue, and is about 585 feet above sea level or 5 feet above the lake.

C. SOUTH OF CALUMET LAKE

South of Calumet Lake (130th Street) and east of Michigan Central Railroad Surface 585 feet A.T.; 5 feet A.L.M. Unio beds beneath Indian graves[2]

Fusconaja undata
Quadrula pustulosa
Elliptio gibbosus
Eurynia recta
Lampsilis ventricosa
Goniobasis livescens

D. NEAR LEMONT

Lincoln Park property, Lemont, near Santa Fe Railroad (Section 16, Du Page County). Surface 595 feet A.T. 15 feet A.L.M

Strata	Deposit	Depth	Remarks
V	Black carbonaceous loam	36	With plant remains
IV	Black carbonaceous soil	26	
III	Peat bed	12	With shells.
II	Marl and silt bed	9	" "
I	Niagara limestone	+	
	Total thickness	83	

[1] By Mr. D. W. Roper, of the Chicago Telephone Company.
[2] Collected by Mr. A. Scharf.

BIOLOGICAL REMAINS

Stratum II

Plants

Potamogeton

Animals

Pisidium compressum	*Segmentina armigera*
" *splendidulum*	*Planorbis antrosus*
" *mainense*	" *campanulatus*
Valvata tricarinata	" *deflectus*
Amnicola limosa	" *exacuous*
" *lustrica*	" *parvus*
Goniobasis livescens	" *trivolvis*
Campeloma integrum	*Galba reflexa*
Physa integra	" *obrussa*
" *warreniana*	*Lymnaea stagnalis appressa*
	Succinea avara

Stratum III

Mollusca

Valvata tricarinata	*Planorbis parvus*
Amnicola limosa	" *trivolvis*
" *lustrica*	*Galba obrussa*
Physa gyrina	" *obrussa decampi*
Segmentina armigera	" *reflexa*
Planorbis exacuous	*Lymnæa stagnalis appressa*

Vertebrata

Odocoileus virginianus	Portion of skull
Fiber zibethicus	Skull

Lincoln Park property, Lemont, edge of Desplaines River. Surface 590 feet A.T.

Strata	Deposit	Depth	Remarks
V	Black loam	28	
IV	Black earth, carbonaceous	12	
III	Brown soil with shells	37	
II	Sticky blue clay	58	
I	Niagara limestone	+	
	Total thickness	135	

E. THE CALUMET-SAG CHANNEL (PLATE XXV)

The Calumet-Sag channel of the Chicago drainage system extends from the Little Calumet River half a mile west of Halsted Street, to the sanitary ship canal about a mile west of Lambert Station (technically from the westerly

reserve line of the Illinois and Michigan canal in Sec. 14, T. 37 N., R. 11 E. of the 3rd P.M. to the north and south center line of Sec. 32, T. 37 N., R. 14 E. of the 3rd P.M.) a length of over 16 miles. The channel is cut in both rock (western end) and dirt (eastern end); the deposits consist of peat, clay, sand, gravel, and boulder clay. The depth of the channel is about 34 feet.

The channel is cut thru the center of the southern arm of the outlet of glacial Lake Chicago, which separated Mount Forest island from the main part of the Valparaiso moraine. The cut should, therefore, clearly reflect the history of the postglacial waters of the Chicago basin, and, except for the physical differences, this history should agree with that shown in the cut of the north shore channel. The physical differences, however, were considerable, the north shore channel being cut thru an old embayment of the lake, while the Calumet-Sag channel is partly in one of the old outlets, which was a large river almost a mile in width. A section of the channel at West 92nd Avenue exhibited the strata shown below.

Calumet-Sag channel at west 92nd Ave. Surface 593.5 A.T.; 13.5 A.L.M.

(Plates XXVI, XXVII)

Strata	Deposit	Depth	Remarks
IX	Surface soil; oxidized peat	24	
VIII	Peat, almost pure	114	Shells and plants, especially in lower part.
VII	Peaty clay	12	Pockets of shells in lower part.
VI	Clay, sandy in lower part	48	Upper part impalpable clay.
V	Fine gray sand	24	But few shells.
IV	Fine sand, coarse sand and fine gravel; sand cross bedded in some places; lenticular pockets of fine gravel, shells, and wood, apparently beach worn	51	Some large stones and a few naiad shells.
III	Boulders, clay, sand, pebbles; boulder pavement on top of till	2	Naiad shells on surface.
II	Boulder clay	65	Very hard.
I	Niagara limestone	78	
	Total thickness	408	=34 feet.

BIOLOGICAL REMAINS

Stratum III

Elliptio crassidens | *Campeloma integrum*
'' *gibbosus* | " *integrum obesum*

Pleurobema coccineum magnalacustris
Crenodonta undulata
Fusconaja undata
Eurynia recta
Lampsilis ventricosa
Pisidium virginicum
Goniobasis livescens depygis
Vavata tricarinata
Amnicola limosa
" *lustrica*
Physa warreniana
Planorbis deflectus

Stratum IV. (One foot from bottom)

Quadrula pustulosa
Fusconaja undata
Sphaerium acuminatum
Pisidium virginicum
" *compressum* (variable)
" *splendidulum*
" *medianum*
Goniobasis livescens depygis
Amnicola limosa
" *lustrica*
Valvata tricarinata
" *tricarinata simplex*
" *tricarinata confusa*
" *tricarinata unicarinata*
Planorbis antrosus
" *parvus*
" *deflectus*
Physa warreniana
Galba obrussa exigua
" *palustris*

Stratum IV. (Two feet from bottom)

Pisidium virginicum
" *compressum*
" *splendidulum*
Sphaerium occidentale
Sphaerium acuminatum
Goniobasis livescens depygis
Campeloma integrum obesum
Valvata tricarinata
" *tricarinata simplex*
" *tricarinata confusa*
Amnicola lustrica
Amnicola limosa
Physa warreniana
" *integra*
" *walkeri*
Planorbis antrosus
" *campanulatus*
" *parvus*
" *deflectus*
Galba obrussa decampi
" *palustris*
" *woodruffi*

Stratum IV. (Three feet from bottom)

Sphaerium acuminatum
Pisidium virginicum
" *compressum*
" *fallax*
" *splendidulum*
" *medianum*
Goniobasis livescens depygis
Campeloma integrum (1 *reversed*)
Amnicola limosa (many forms)
" *lustrica*
Valvata tricarinata
" *tricarinata simplex*
" *tricarinata confusa*
Physa warreniana
" *integra*
" *walkeri*
Planorbis antrosus
" *campanulatus*
" *parvus*
" *deflectus*
Segmentina armigera (1 spec.)

Stratum IV (Top of sand deposit)

Elliptio gibbosus
Sphaerium acuminatum
Pisidium virginicum
Goniobasis livescens
Valvata tricarinata
Amnicola limosa
" *lustrica*
Physa integra
Planorbis parvus
Galba obrussa
" *palustris*

Stratum VII (Just above clay)

Animals

Naiad, fragments	*Planorbis antrosus*
Anodonta species	" *exacuous* (rare)
Valvata tricarinata	" *parvus*
Amnicola limosa	*Ancylus parallelus*
" *lustrica*	*Galba palustris*
Physa warreniana	" *reflexa*
Planorbis campanulatus	*Lymnæa stagnalis appressa*
Donacia proxima	*Coleoptera*, punctostriate elytron

The till beneath these sedimentary deposits is a portion of the Valparaiso moraine, exhibiting the charactertistic undulating topography of a terminal moraine. A mile or so west of the 92nd Street section, the naiad deposit and the boulder pavement come within five feet of the surface, the boulder clay increasing in thickness and the peat deposit decreasing in thickness. A few hundred feet farther west these deposits again fall away to the bottom of the canal. This elevation may have been an island during one of the low water stages. The sequence of strata is the same in all locations, the variation being in the relative thickness of the deposits. The interpretation of these deposits may be summarized as follows:

Stratum II, boulder clay. This deposit is very hard and contains an abundance of rock material.

Stratum III, boulder pavement, sand gravel. This stratum evidently represents the Glenwood, Bowmanville, and Calumet stages. During the Glenwood stage there would be some erosion of the boulder clay, notably, when the water was lowering, preceding the Bowmanville stage. It was at this period, probably, that the boulder pavement was formed. Later, during the Bowmanville stage, a little clay was deposited, and, as the water was rising to form the Calumet stage, a little gravel resulted. The bed of Unio shells lying on the surface of this boulder pavement was probably deposited during the latter part of the Calumet stage and the early part of the Toleston stage.

Stratum IV, sand and gravel. The heavy bed of fine gravel and sand was evidently formed during the low water period succeeding the Toleston stage as it contains much beach-worn wood, worn shells and the usual mixture found on a gravel y shore or in shallow water where there is somewhat of a current, a condition easily provided by an outlet from a shallow lake such as Lake Chicago is supposed to have been at this time. As the moraine beneath these deposits is notably rolling the deep gravel and sand deposit may rest against one of these dome-shaped elevations, which may have been near the surface during this time.

Stratum V, fine gray sand. This deposit is believed to represent a time when the water was rising to form the Hammond stage.

Stratum VI, clay. The clay deposit is believed to represent the bottom of the lake during the Hammond stage. The upper part of this deposit may have been a land surface during the low water period.

Stratum VII, peaty clay. This deposit contains many shallow water mollusks and probably represents the Englewood stage (Nipissing stage) at its highest level.

Stratum VIII, peat. This thick bed of peat indicates a shallowing of the water and records a change from flowing water to swampy conditions. At this time the lake had ceased to discharge thru the Chicago outlet.

Stratum IX , surface soil. This deposit represents the recent period when the area had changed to a swamp, such as existed in the Sag region before the canal was excavated.

The interpretation indicated above may be graphically expressed in the diagram on plate XXVIII, which indicates the depths of water at each stage.[3]

F. SCATTERED RECORDS

There are a number of records of life in the museum of the Chicago Academy of Sciences, and in local literature, which cannot be referred to any particular sedimentary deposit, tho belonging undoubtedly to postglacial fossil strata. These are listed below, with comments.

Corner Wrightwood Avenue and North Clark Street

Fusconaja undata.[4] In excavation for building. In Toleston beach.

Corner Frederick and North Clark Streets

Crenodonta undulata.[4] In excavation for building. In Toleston beach.

Corner Sheffield and Lincoln Avenues

Goniobasis livescens[4] *Pleurocera subulare*

These possibly belong to the Toleston stage. No geological data was supplied with the specimens.

Balmoral Avenue, Bowmanville

Goniobasis livescens.[4] This record is on the Calumet beach but should probably be referred to the Toleston stage.

Summit, bed of Sanitary Canal

Sphaerium sulcatum	*Valvata tricarinata*
Amnicola limosa	*Planorbis deflectus*
" *lustrica*	" *parvus*

[3] It is greatly to be regretted that there has been no opportunity to give to the Calumet-Sag channel the careful study accorded the north shore channel. The writer was able to visit the excavations of the Calumet-Sag canal but a few times, and while the information secured is of value and corroberates the interpretations given to the north shore deposits, it is still true that much interesting information has been lost. Science is apparently not yet in position to take full advantage of the opportunities which commerce and industry so often provide, frequently at great expense.

[4] Collected by Mr. Carl Dilg.

No record was kept of the stratum from which these shells came, but they are believed to be referable to the Hammond stage of Lake Chicago.[5]

Corner of West Monroe and Morgan Streets

Unio shells[6]

Chicago Heights

The tooth of a mammoth (*Elephas columbi*) was found in the bank of Wallace Creek, at a depth of 18 or 20 feet.[7] This creek flows in the Valparaiso moraine in which it has sunk its bed for twenty feet or more. The tooth was probably washed from a higher source. It is impossible to determine with just which lake stage the fossil is to be correlated; it is, however, certainly postglacial.

IV. Typical Sections of Beaches

A. GLENWOOD BEACH

Haas' gravel pit, Oak Park. Surface 625 feet A.T.; 45 feet A.L.M.[8]

Strata	Deposit	Depth
1	Brown-stained gravel, capping summit and slope	18-30 inches
2	Fine gravel, fresh or stained but little	24-48 "
3	Sand, very thin at top, but increasing toward side of bar	0-36 "
4	Fine gravel, increasing like no. 3	0-48 "
5	Fine gravel, nearly 4 feet in thickness, which passes upward from near the east side of the excavation, assuming a nearly horizontal position beneath the crest of the ridge	40-48 inches
6	Sand, thickening toward the higher part of the ridge	6-36 "

[5] It is exceedingly unfortunate that systematic records and collections were not made when the large drainage canal was being excavated. Its entire length is in the bed of the old outlet, and, judging by the fragmentary records which are obtainable from this region, it undoubtedly presented quite as fully the biological history of Lake Chicago as did the strata uncovered in the north shore channel.

[6] Higley and Raddin, p. XV. It is not known from what horizon these specimens were obtained.

[7] Collected by Mr. James H. Knapp. Identified by Dr. O. P. Hay.

[8] Leverett, Pleistocene Features, p. 70. This section is on the Oak Park spit and not in the beach proper, which attains an elevation of 50 feet.

B. CALUMET BEACH. (PLATE XXIX)

About 1500 feet south of the Lake shore, North Evanston, Station 60. Surface 610 feet A.T. 30 feet A.L.M.

Strata	Deposit	Depth	Remarks
VII	Black sand	9 inches	
VI	Black sand and gravel	85 "	More or less stratified in lower part.
V	Gray sand (fine)	15 "	With wood in strata.
IV	Peat and wood	9 "	
III	Gravel and sand	5½ "	
II	Clay	14 "	
I	Boulder clay	223 "	
	Total thickness	360½ "	=30 feet.

C. TOLESTON BEACH

North of Montrose Boulevard and east of Dover Street. Surface 600 feet A.T.; 20 feet A. L. M. 20 feet A.L.M.

Strata	Deposit	Depth	Remarks
XII	Fine yellow sand	66 inches	
XI	Gravel and sand	6 "	
X	Gray sand	3½ "	
IX	Gravel	2 "	Varies in thickness.
VIII	Gray sand	4½ "	
VII	Gravel	1 "	
VI	Fine gray sand	5 "	
V	Gravel and coarse sand	6 "	Varies in thickness.
IV	Gravel	10 "	
III	Gray sand	6 "	
II	Gravel	15 "	
I	Gray sand	27 "	
	Total thickness	152 "	=12 feet 8 inches

North end Northwestern University campus, near foot of Noyes Street (Plate IV).

Strata	Deposit	Depth	Remarks
X	Yellow sand and gravel	69 inches	
IX	Sand and gravel, cross bedded	18 "	
VIII	Yellow sand	18 "	
VII	Very fine, compact silt	14 "	With shells.
VI	Peaty, with fine sand	2 "	With plant stems.
V	Carbonaceous matter mixed with sand and roots	7 "	
IV	Fine yellow sand	51 "	
III	Vegetable matter and fine sand interstratified	1½ "	
II	Fine yellow sand	18 "	
I	Water-laid clay, oxidized in upper part	67 "	
	Total thickness	265½ "	=22 feet 1½ inches.

The top of the compact silt (stratum VII) varies but little in height above Lake Michigan west of the above section, which was made on the east face of the beach. Dr. U. S. Grant, has kindly measured this elevation, which is as follows:

Section on face of beach	13.57	feet above Lake Michigan
Twenty feet to the west	13.50	" " " "
Thirty feet to the west	13.82	" " " "
Forty feet to the west	13.47	" " " "
Forty feet to the west	13.72	" " " "
Forty feet to the west	14.82	" " " "
Fifty feet to the west	13.97	" " " "
Fifty feet to the west	14.02	" " " "

It is interesting to compare this recent section of the Toleston beach with the previous sections of Marcy and Leverett.[9] The two carbonaceous layers (strata VI and III of the 1912 section) are repeated, and the fine silt deposit contains molluscan shells. As these peaty deposits have been found in various parts of Evanston, and also as far west as the north shore channel, it seems evident that they represent low water periods when the surface was exposed and grass and trees grew upon it. It is to be noted that the carbonaceous strata of Leverett's section are closer together than in Marcy's or Grant's sections.

Many years ago, Dr. Oliver Marcy, (now deceased) of Northwestern University, collected a number of shells from stratum number 7 of his 1864 section (Plate IV, section I, number 4) which were identified by Mr. C. T. Simpson

[9] Pleistocene Features, p. 76.

and referred to nine genera. Some years ago a number of these shells were submitted to the writer and the following species were observed.

Galba palustris	*Physa warreniana*
" *reflexa*	*Ancylus* species (broken)
" *caperata*	*Goniobasis livescens*
Planorbis trivolvis	*Pleurocera elevatum*

A search recently made by Dr. Grant failed to disclose the shells from the Evanston deposit, in the museum of the Northwestern University, and it is probable that they were packed away by Dr. Marcy and have escaped observation. The Unios cannot, therefore, be identified. In stratum VII of Grant's section the following species were noted.

Amnicola lustrica	*Planorbis trivolvis*
	Planorbis parvus

No plants have been specifically identified from the carbonaceous strata of the 1912 section. In Marcy's section, however, plants and other life were identified as noted below.

Strata	Marcy's No.	Plate IV, I	Deposit	Species
Stratum	5	6	Gravel	*Odocoileus virginianus* (femur)
"	6	5	Sand	*Quercus marcyana* (wood)
"	9	A	Humus	*Picea evanstoni* (wood)

The *Quercus* has not been rediscovered in any of the recent deposits studied.

V. Previous Glaciations in the Chicago Area

It is believed that at least one interglacial interval, preceded by an extensive glaciation, is represented in the glacial deposits of the Chicago Area. Leverett[10] gives evidence showing the presence of a preglacial valley beneath the drift, which entered the great valley now occupied by Lake Michigan near Lincoln Park. This small valley may be traced westward for several miles, the depth to rock being from 115 to 125 feet.

Old soil zones have been observed in many wells in and about the Chicago region. In the northwestern part of Cook County a black soil is penetrated at a depth of over 100 feet. At Arlington Heights a black soil was observed at a depth of 70-75 feet. A well section in township 41, range 10 east, gave the following log:

Yellow till	10-15 feet
Blue till	125 "
Black soil	4 "

[10] Illinois Glacial Lobe, pp. 583-587.

Sandy till	50	feet
Gravel with water	2	"
Total thickness	196	"

It is believed that the till sheet beneath this old soil represents the Illinoian glaciation and the old soil the Sangamon (and possibly the Peorian) interglacial interval. It is probable that lake deposits similar to those recorded in the preceding pages were formed during this interglacial stage, but the evidences of such have been obscured or obliterated by the later Wisconsin glaciation.

VI. Summary

The data set forth in the pages of this chapter may be summarized as follows:

1. Above the boulder clay there is usually a layer of sand, varying in thickness from the fraction of an inch to twelve inches. This varies in composition from fine sand to coarse sand and gravel.

2. Superimposed upon this sand layer is a bed of silty, carbonaceous, or peaty material, varying in thickness from one to forty inches. This is sometimes interstratified with one or more beds of sand. This stratum contains numerous fresh water shells belonging to shallow water species. Oak leaves and spruce cones are associated with the shells.

North of Devon Avenue, and extending as far as Wilmette, the equivalent of this stratum is represented by a strongly oxidized covering of the boulder clay, the upper ten to forty inches of the latter being filled with rootlets of the vegetation which grew upon the oxidized surface. This old land surface has been reported from many parts of Evanston. Leverett says,[11] "some of the sewer ditches in Hyde Park, west of Grand Boulevard, have reached peat deposits below sand, at a level a few feet above the lake." This deposit is probably the same as the one found in the north shore channel and elsewhere. In the Ogden ditch, near Austin Avenue, a peat deposit occurs below a Unio bed. Near Oak Park and Ogden avenues a silt deposit is found, below sand, which is oxidized. In the Calumet-Sag channel the boulder pavement may represent this episode.

The geological character of these deposits, and especially their biological contents, leads at once to the conclusion that they represent a low water stage of glacial Lake Chicago, the waters of which were warm enough (cold temperate) to support a varied molluscan fauna. Oak and spruce grew upon the higher ground. The lake at this stage could not have been higher than about ten feet above the present datum or 590 feet above tide.

3. The silt and peaty deposits are covered by gravel and sand from 2 to 19 inches in thickness. This deposit varies in character from fine sand of a silty

[11] Pleistocene Features, p. 51.

consistency, to coarse gravel, approaching shingle. This stratum has been encountered everywhere in the Chicago basin where excavations have been made. On the beaches and bars the sand is piled up to a depth of 17 to 25 feet. The Fullerton Avenue conduit, which extends from the Chicago River into the lake, cuts thru the lower beach (on Clark Street) giving an excellent section of this formation. Of this conduit Leverett says,[11] "The sand has its greatest thickness at about 1,700 feet from the lake, where it reaches 25 feet.[12] It decreases westward to 17 feet at 2,100 feet from the lake, and to 12 feet at 6,000 feet,[13] and entirely disappears before reaching the Chicago River valley. Toward the lake shore it also decreases, being about 18 feet in depth for 1,400 feet west from the shore. At the waters edge the depth is about 10 feet. The profile continues out 1,100 feet below the lake, and there is but 3 feet of sand at its terminus."

The deposits discussed above include the material which formed the Graceland bar and the Toleston beach and are not homologous with the sand and gravel deposits discussed under this section, altho they probably include these deposits in the lower part of the strata. Altho Leverett states that the sand entirely disappears before reaching the Chicago River valley, the writer observed sand and gravel deposits in various localities for a considerable distance down the valley on the banks of the river, near the water's edge. South of Lawrence Avenue, they are mostly below the surface of the river.

4. Resting on and in the upper part of the gravel deposit is a heavy bed of Unios and other mollusks. This bed has been observed in many parts of Chicago, and its presence is assumed to be as universal as are similar beds which are found today in our large rivers. In the north shore channel, they have been observed from Montrose Boulevard to Devon Avenue, a distance of about two and one-half miles. The same deposit occurs at Austin Avenue and Ogden ditch, and in the Calumet-Sag channel. North of Devon Avenue this deposit does not occur, showing that the water was not deep enough for the heavy Unios.

5. Above the Unio beds occur deposits of silt, sand, peat, and marl beds, varying from 19 to 59 inches in thickness. The lower deposit of silt or sandy-silt is usually devoid of life; but the upper layers are filled with mollusks and fish remains representing species which live in comparatively shallow water. In several localities distinct marl beds occur which are solid masses of shells. The upper part of the silt deposits is oxidized, giving indisputable evidence of a former land surface. This stratum also contains the burrows of crayfish and the remains of *Potamogeton*, *Chara*, and *Najas*, all evidences of shallow water. North of Devon Avenue the silt deposits above the gravel contain the remains of mollusks which live in very shallow water or in swales and marshes.

[12] Clark Street, the crest of the Toleston beach.
[13] West of the St. Paul tracks.

6. This apparent land surface is covered by silt or peat beds, with an occasional thin sand layer. Mollusks are abundant in places. These strata are covered with a silty layer containing the plant *Potamogeton*, indicative again of shallow water. The upper silt deposits are oxidized and contain crayfish burrows, which are evidences of a land surface. The peat beds are apparently local and were possibly laid down in kettle holes in the ground moraine. These deposits vary from 15 to 52 inches in thickness.

7. These deposits are everywhere capped by sandy-silt or peat deposits changing to loam at the surface, averaging about 20 inches in thickness. The lower part of the deposit contain the shells of shallow water mollusks. In the Calumet–Sag channel the upper peat deposit is in places over 11 feet in thickness.

Standing out clearly in the foregoing summary are the following significant facts:

1. A low water stage early in the lake's history.
2. A period of strong gravel formation indicating a rising water body.
3. Two land and low water stages separated by water bodies of varying depth.

This interpretation, based on the north shore channel deposits, is expressed in Plate XXX.

The data set forth in the preceding pages are considered in chronological order, the biological significance being given first place, in the chapter that follows.

CHAPTER III

THE LIFE OF GLACIAL LAKE CHICAGO AND ITS SUCCESSORS

I. General Statement

In subsequent chapters the Ice Age is discussed and its different stages, both glacial and interglacial, are considered. In the present chapter only the life of Lake Chicago, and its immediate successors, is discussed, the interglacial stages, as well as the postglacial territory lying beyond Chicago, being reserved for succeeding chapters. The discussion is taken up chronologically in order that the evolution and migration of the biota may be clearly shown. Comparisons are made with recent lake areas in New York State, as they plainly illustrate a part of the history of the formation of old Wilmette Bay.

II. Waning of the Wisconsin Ice Sheet and Formation of Ponded Waters

As the ice receded in the Mississippi Valley, several bodies of water were formed at the ends of three lobes known respectively as the Erie lobe, the Michigan lobe, and the Superior lobe. These lakes were bounded on one side by the ice and on the other sides by high portions of the land surface, usually moraines. These bodies of water, known as lakes Maumee, Chicago, and Duluth, drained into the Mississippi river via the Wabash, Desplaines, and St. Croix rivers. There is believed to have been, also, a lake (Lake Jean Nicolet) southwest of Green Bay which drained thru the Wisconsin River. By these water routes the biota advanced northward and reoccupied the glaciated territory (Plate XXXI). Of these water bodies only one, Lake Chicago, is considered in detail in this chapter.

III. Glacial Lake Chicago

The body of water formed at the extremity of the Michigan lobe has been given the name of Lake Chicago by Mr. Leverett.[1] This lake stood at various levels which are marked by more or less well-developed beaches. These beaches indicate well defined stages, several of which embraced the entire Great Lakes system.[2]

[1] Pleistocene Features, pp. 64-65, 1897.

[2] The physical history of the formation of the Great Lakes has been well described by Alden, Leverett, Goldthwait, and Taylor (see Bibliography).

A. THE GLENWOOD STAGE[3] (PLATE XXXII)

The initial stage of Lake Chicago is known as the Glenwood. As the ice melted back of the Valparaiso moraine, a crescent-shaped body of water came into existence, which stood at a height of 60 feet above the present level of the lake for a period, but soon fell to 55 feet, after cutting thru the lowest notch in the Chicago outlet below Lemont. At this stage the southern portion of the lake extended from Winnetka west and south to Norwood Park, Oak Park, LaGrange and Palos Park, southeast to Glenwood, Illinois and Dyer, Indiana, continuing easterly and northeasterly thru northern Indiana and southwestern Michigan. Mt. Forest and Blue Island were conspicuous islands, and the Desplaines River and the Sag formed two wide outlets, thru which the gathering waters probably rushed with great velocity, finding an outlet in the Illinois and Mississippi rivers. Three bays of considerable size were formed: Skokie Bay and Chicago Bay (the latter being apparently almost as large as Skokie Bay) on the north and Desplaines Bay on the west. Well-marked sand spits developed across the mouth of Skokie Bay and of Desplaines Bay, known respectively as the Skokie spit and the Oak Park spit. Small bays existed on the southern shore of the lake, as at Dyer, Indiana. The large bays were doubtless swampy at their heads and along their shores.

Life

There is no evidence of aquatic life during the Glenwood stage; this is as would be expected in the icy waters melting from the glacier. The mastodon and mammoth probably wandered along the beach. The remains of these animals have been found in Haas' gravel pit in Oak Park,[4] and near Evanston, Glencoe, Naperville, and Wheaton.[5] The oyster shells and other mollusks mentioned by Leverett[6] were probably introduced by early natives in graves. The writer has examined this and other gravel pits on the Glenwood beach and no evidences of life have been found.

B. THE BOWMANVILLE LOW WATER STAGE[7]

The Glenwood high water stage was followed by a period of low water when the level of the lake fell to about 10 feet above the present level. Conclusive

[3] The maps of Lake Chicago have been compiled from the works of Leverett, Alden, and Goldthwait, with a few additions by the author.

[4] Leverett, Pleistocene Features, p. 71.

[5] Anderson, A Preliminary List of Fossil Mastodon and Mammoth Remains in Illinois and Iowa, pp. 9-10.

[6] Pleistocene Features, p. 70.

[7] As this stage seems equal in value to the Glenwood, the Calumet, or the Toleston stage it is given a distinct name. As its development is most pronounced near the old village of Bowmanville, this name is suggested for the stage.

data are supplied by a bed of very fine silt and peat, 10 to 18 inches in thickness, which overlies the thin bed of Glenwood sand or lies directly upon the boulder clay. This low water stage is affirmed by Leverett,[8] Alden,[9] and Andrews,[10] but is questioned by Goldthwait,[11] who refers the peat deposit underlying the Calumet beach to the Toleston stage. Leverett [11a] has recently questioned the age of the deposits found below sand and gravel at Bowmanville, and believes that further evidence of the supposed low water stage should be found in the valleys draining into Lake Chicago, suggesting that the remains of the Calumet beach should be found across these valleys which should have cut thru these valley floors to the level of the low water stage. It is probable, however, that in the vicinity of Chicago, at least on the North Shore, the destruction of the shore by Lake Michigan in recent times has destroyed much of this evidence. The lake waters may also have cut the outlet down to the Calumet level before the low water stage. The suggestion is of value in this connection and should be followed when opportunity permits. Alden[10a] later questions the low water stage between the Glenwood and Calumet stages, accepting the conclusion of Goldthwait that "the peat is merely a lacustrine deposit formed in quiet water behind a barrier during the Calumet stage and buried by shoreward advance of the bar." The presence of this extensive and wide-spread silt deposit, with its abundance of shallow water life, is, however, strong evidence of the truth of Dr. Andrews' early contention of a post-Glenwood low water stage. This deposit extends as far north as Devon Avenue, to the 590 foot contour.

The humus soil mentioned by Andrews, Leverett, and Alden, possibly represents a land surface correlative with the post-Glenwood stage, altho it might represent a marsh formation deposited in shallow water behind a bar to the eastward, the evidence of which, however, has been lost by the destruction of the shore in later years. From Devon Avenue to the lake, along the line of the north shore channel, there is a deposit of water-laid clay, of varying thickness, which underlies Calumet gravel and sand, and which contains a mass of roots and rootlets, giving (apparently) conclusive evidence of a post-Glenwood land surface (see figure 1).

If we assume that the depth of water did not exceed ten feet, the outline of the submerged area would appear about as shown in plate XXXIII. Mt. Forest and adjacent territory would have been a large island, with Lane's Island to the south and Stony Island to the east. The outlet formed two broad, shallow rivers. The area covered by water extended from about Wil-

[8] Pleistocene Features, p. 71; Ill. Glacial Lobe, p. 440.

[9] Geog. of Chicago, pp. 32, 40, Chicago Folio, p. 9.

[10] Trans. Chi. Acad. Sci., II, p. 15.

[10a] Professional Paper 106, U. S. G. S., pp .332-333.

[11] Records of Extinct Lakes, p. 61.

[11a] U. S. Geol. Surv., Mon. LIII, pp. 356, 357.

mette on the north to a point between the Little Calumet and the Grand Calumet rivers on the south. It extended on the east into southwestern Michigan. A small bay must have developed from Foster to Devon avenues, which was protected from the rough waters of the lake by a long bar. A suggested outline of Wilmette Bay is shown in plate XXXIV.

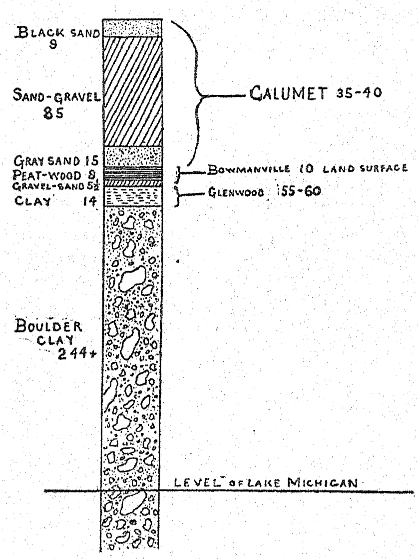

Figure 1. Diagram illustrating position of shallow water and land deposits beneath sand and gravel of Calumet beach. Section of beach ridge south of Gross Point. Figures to left of column indicate thickness of strata (inches). Figures to right of column indicate depth of water (feet) of Lake Chicago at time deposit was made.

a. Life of Wilmette Bay

The life of this stage is characteristic of ponds and lakes, where the water varies from two to ten feet in depth. The life also indicates comparatively quiet waters, free from violent wave action. It is possible that bars, reefs, and spits were formed to the eastward and later destroyed by the rising of the water. The species of plants and mollusks contained in this deposit are tabulated below:

Plants

Quercus species	*Picea canadensis*
Populus balsamifera	*Larix laricina*
Abies balsamifera	*Carex* sp.
Thuja occidentalis	

Animals

Anodonta grandis	*Amnicola emarginata*
" *grandis footiana*	" *limosa*
Propiera alata	" *lustrica*

Lampsilis luteola	*Campeloma integrum*
Sphaerium sulcatum	" *integrum obesum*
" *solidulum*	*Physa warreniana*
" *striatinum*	" *gyrina*
" *flavum*	*Ancylus fuscus*
" *stamineum*	*Ancylus parallelus*
" *stamineum wisconsinensis*	*Segmentina armigera*
" *acuminatum*	*Planorbis trivolvis*
Pisidium affine	" *campanulatus*
" *compressum*	" *antrosus*
" *idahoense*	" *deflectus*
" *variabile*	" *exacuous*
Valvata tricarinata	" *parvus*
Goniobasis livescens	*Galba reflexa*
	" *palustris*
	Lymnaea stagnalis appressa

The majority of the species are represented by a multitude of individuals showing that life was abundant during this period. All of the species are north temperate and boreal in distribution; many, indeed, extend as far north as the 60th and 70th degrees of north latitude. It is not remarkable, therefore, that this life should have followed so closely the retreating ice. The oak, spruce and other conifers are also indicative of a cold-temperate climate; the spruce does not now live within about one hundred miles of Chicago, and the other trees are of northern distribution. The late Prof. Penhallow[12] compared the spruce found at Evanston to *Picea sitchensis*, a species of the west coast of America. The spruce found in the north shore channel has been identified as *Picea canadensis*, which is abundant in southern Michigan and Wisconsin, and extends northward to Alaska and Hudson Bay.

The number of specimens of the cones and the wood of the spruce, and the wood and leaves of the oak, and other trees point to the abundance of these species during this period. Of the spruces Prof. Davis said: "These conifer remains occur in such abundance in the sandy material that it would seem highly probable that the trees from which both the leaves and cones came, must have been abundant in the immediate vicinity of the lake during the time when the deposits were being formed. It does not seem likely that so much material of this sort, unmixed with other plant remains could have been washed down the shore of the lake from the north, for any distance, and at the present time, *Picea canadensis* is found only a considerable distance to the north of your locality."

As the strata containing these evidences of life do not extend far beyond Devon Avenue, or a mile and a half north of Foster Avenue, it is apparent that the level of the lake could not have been much over ten feet higher than the present level. The ground moraine in this area is notably undulating, forming

[12] Trans. Roy. Soc. Canada, IX, pp. 29-32, 1891.

"kettle-holes" of considerable size. Several of the elevations of the ground moraine are of such height, from nine to fifteen feet, that they may have formed little islands in the shallow lake (see plate XXXIV). A notable example is near Lincoln Avenue, where the boulder clay of the ground moraine is exposed on the surface for nearly half a mile. If the level of the lake was as low as the present level, as has been suggested by Leverett, these depressions might have contained ponds or pools, similar to many which may now be found in the Skokie marsh area. The presence of such mollusks as *Anodonta*, *Lymnaea*, *Amnicola*, and *Campeloma* rather disprove this theory, however, as these species live in lakes or ponds usually having connection with a lake or river of some size. The species of mollusks contained in these lower deposits, together with the stratigraphical character of the deposits, both lacustrine and terrestrial, point to the conclusion that they were formed in shallow water, not exceeding ten feet in depth, which was protected from the violence of the waves on the east by a low sand bar, subsequently removed by the rising of the water preceding the Calumet stage.

b. Other Deposits Belonging to this Stage

A marl deposit was observed near the Ogden ditch, on Austin Avenue, which probably may be correlated with the deposits previously mentioned. It underlies five feet of peat and silt (the latter with naiads) and contains the following species of mollusks:

* *Pisidium tenuissimum*	* *Valvata tricarinata unicarinata*
" *medianum*	*Physa warreniana*
* *Musculium truncatum*	* " *walkeri*
* " *secure*	*Planorbis antrosus*
Amnicola limosa	" *campanulatus*
" *lustrica*	" *parvus*
	* *Galba obrussa decampi*

It will be noted that six species and one race are found in this deposit which are absent from the two deposits previously discussed. These are indicated by an asterisk in the list.

The richness of the molluscan fauna of the Bowmanville low water stage is indicated in the following table (species and races treated alike):

Anodonta	2	*Goniobasis*	1
Proptera	1	*Campeloma*	2
Lampsilis	1	*Physa*	3
Sphaerium	7	*Ancylus*	2
Musculium	2	*Segmentina*	1
Pisidium	6	*Planorbis*	6
Amnicola	3	*Galba*	3
Valvata	2	*Lymnaea*	1
		Total species	43

c. Cause of Low Water Stage

Just what may have caused the level of the water of Lake Chicago to fall is not definitely known. The uncovering of a lower outlet to the northeast is suggested by Leverett[13] and Alden.[14] The readvance of the ice mentioned by Alden[15] and Goldthwait[16] may have succeeded this low water stage. The red clays, which are buried under Calumet beach deposits, appear to have been left in a retiring water body.[17] Goldthwait[18] has suggested that the peat deposits mentioned by Andrews, Leverett, and Alden, might be "a lacustrine deposit, formed in quiet water behind the barrier during the Calumet stage, and buried by shoreward advance of the reef." This seems scarcely possible, in view of the data at hand, as these deposits are widespread and have been found in most places where excavations have been made, and, as recorded by Andrews, underlie both the Calumet and Toleston beaches.

Leverett says[19] "The peat not only underlies the bar under discussion (the Rose Hill bar), but extends eastward across the interval between it and the third beach.** There seems no escape from the conclusion that the lake stood at a lower stage than the level of the second beach before that beach and the bar under discussion were formed" (See figure 1). Leverett's statement is substantiated by the character of the deposits found in the north shore channel, and the post-Glenwood low water stage must, therefore, be admitted as having existed.

Leverett's and Alden's suggestion of an outlet to the northeast is not tenable. Until the coalescence of the waters of the Michigan basin with those of the Superior and Huron basins to form Lake Algonquin, the history of Lake Chicago (as far as known) was quite distinct from that of the northern and eastern basins. The Algonquin stage occurred long after the low water stage under discussion. The cause of the variation in level of Lake Chicago must, therefore, be looked for in the fluctuation of the glacial lobe in the Michigan basin. It is known that the ice margin retreated and advanced several times in the Huron–Erie–Ontario basins, these fluctuations opening new outlets and affecting the level of the water in these basins. Corresponding changes occurred in the Michigan basin, and it is probable that to these we must ascribe the early changes of level of Lake Chicago. The ice of the Michigan lobe left two moraines which indicate as many advances of the ice

[13] Pleistocene Features, p. 71.

[14] Chicago Folio, p. 9; Delavan Lobe, p. 70.

[15] Milwaukee Special Folio; Science, XXIX, p. 557, 1909.

[16] Abandoned Shore Lines, pp. 2, 40.

[17] Alden and Leverett.

[18] Records of Extinct Lakes, p. 61.

[19] Pleistocene Features, p. 74.

front; one at Milwaukee (correlative with the Port Huron–Whitehall moraine) and one at Two Rivers, Wisconsin (believed to represent the Manistee moraine).

During one of these retreats the ice may have opened an outlet north of the Green Bay Valley which caused a lowering of the lake level. Writing of the changes in the Michigan basin, Taylor says,[20] "Bordering the west shore of Lake Michigan and extending into the Green Bay—Lake Winnebago trough and the Fox and Wolf River valleys is an extensive deposit of red clay, partly laminated, partly pebbly and massive, which was described by Chamberlin in his Geology of Eastern Wisconsin. Later study of this deposit by Alden, under the direction of Chamberlin, shows that the larger part of this deposit, the massive pebbly clay, is to be interpreted as glacial till which was laid down during a readvance of the glacier in the Lake Michigan basin as far south as Milwaukee and of the Green Bay lobe in the Green Bay–Lake Winnebago trough to a point south of Fond du Lac, Wis. The ice also crowded westward in the Fox and Wolf River valleys. The red silt composing the laminated clay and the matrix of the massive pebbly clay is thought to have come from the Lake Superior region, being brought into the Green Bay and Lake Michigan basins by the opening of a southward outlet southeast of Marquette. The first opening of this outlet must have been at or near the climax of the stadial retreat immediately before the readvance to the first red till moraine. The phenomena indicate a readvance over a relatively wide interval, and it seems certain that if a lower outlet had been opened by the retreat, it was closed again by the readvance and the level of the glacial waters in the western half of the Lake Superior basin were raised again to the level of some earlier, higher outlet. Perhaps this accounts for the faintness of some of the beaches immediately above the Algonquin beach in the Lake Superior basin; they may have been submerged and obliterated after they were made." These fluctuations may have affected the level of Lake Chicago. Professor Upham[21] believes that Lake Chicago flowed thru a glacial lake which he calls Lake Jean Nicolet (via the Wisconsin River to the Mississippi River) during this low water stage, and that the Green Bay region has been uplifted since that time. This opinion seems untenable because the divide at Portage is too high (797 feet above sea level) for an overflow at the Bowmanville stage (590 feet).

Just what relation the Bowmanville stage may bear to glacial Lake Wayne of the Huron–Erie–Ontario basins can only be surmised. This lake followed Lake Whittlesey, the waters falling 80 or 85 feet. This drop in level was due to further retreat of the ice, which uncovered an opening along the ice front near Syracuse, into the Mohawk Valley. Taylor says,[22] "When the Huron–Erie

[20] Smith. Report, 1912, p. 313.

[21] Amer. Geol., XXXII, pp. 105-115; 330-331, 1903.

[22] Smith. Rep., 1912, p. 313; also 305-306.

waters were discharging eastward past Syracuse, the volume of discharge at Chicago was largely diminished and the lake stood slightly lower."

Goldthwait[23] has recorded a forest bed (containing peat, sticks, logs, and tree trunks, some of the latter still standing) at Two Creeks, Manitowoc County, Wisconsin, which is covered by 12 feet of stony red till. This is evidently a part of a moraine laid down during a readvance of the ice. The correlation of this forest bed, in time, with the Bowmanville deposits seems probable (See Chapter IV under Wisconsin for a discussion of this deposit). The old forest bed and the red clay are widely distributed in the Green Bay Valley, showing that this period was widespread, and the episode must have been of a duration sufficient for the growth of an extensive forest.

Recent studies in southeastern Wisconsin carried on by Alden[24] suggest that the Bowmanville low water stage might have occurred during the Glenwood stage. The red till of the Whitehall–Port Huron moraine, near Milwaukee, covers the sands and gravels of the Glenwood beach (see Alden's figure 18, page 311) showing that this moraine covered the high beach north of Milwaukee. South of Milwaukee this beach is continuous and vigorous but "north of this place there was an early Glenwood stage, then a stage of glaciation followed by a later Glenwood stage" (p. 311). It would not be impossible for the Bowmanville low water stage to have occurred between these two Glenwood stages especially if an outlet was uncovered somewhere to the north which has been elevated since by differential uplift. The life of the Bowmanville stage is such as would be likely to be found in the cold waters of a lake in which a glacier was several hundred miles away. The low water stage might, therefore, have been inter-Glenwood instead of post-Glenwood and pre-Calumet. In this case there would be good evidence for a sudden drop from the Glenwood level to the Calumet level of the lake.

Whatever may have been the cause of the low water stage, its existence seems beyond question and its place between the Glenwood and Calumet beaches is attested by excavations in many places. It is also possible that before the low water period the Chicago outlet had been cut down sufficiently to lower the level of the lake to 40 feet above the present level, as the subsequent stage did not rise above the Calumet beach which is at this height. As the level of the lake during the low water stage was about ten feet above datum, the Chicago outlet could not be used and the outlet river formed a long narrow bay. If any deposits were made at this time they were subsequently removed by the water cutting down the outlet. No deposits have been observed in the outlet channels which can be referred to this stage with confidence. The rising of the water which inaugurated the Calumet period again

[23] Abandoned Shore Lines of Wisconsin, p. 61; Lawson, Bull. Wis. Nat. Hist. Soc., II, p. 170; Alden, The Delavan Lobe.

[24] Professional Paper 106, U. S. G. S., pp. 134, 311, 327, 1918.

flooded the lands laid bare by the lowering of the lake, causing the extinction of the biota in the lake basin, burying it under a heavy deposit of sand and gravel.

C. THE CALUMET STAGE

Following the period of low water, the lake again rose until it stood 35 to 40 feet above its present level (it may have risen to the Glenwood level and then fallen to the Calumet level). The Calumet beaches are usually strongly marked, showing that the lake must have remained at this height (35 feet) for a considerable period. This uniform level was probably made possible by a "sill" of bed rock near Lockport, which offered such resistance that a considerable time was needed to cut thru this material.[25] Goldthwait[26] attributes the bold character of the Calumet beach to a sudden drop from the 55 foot level, caused by cutting thru the valley train in the Desplaines[27] Valley, but it was more likely formed (viewed in the light of the post-Glenwood low water stage) by the rising of the water level which cut cliffs and built up terraces. The sand overlying the post-Glenwood silt and peat beds was evidently largely deposited during the rising of the lake, as it is so widely distributed over the lake plain; it varies in thickness from 2 to 19 inches, and in character from fine sand to coarse gravel.

At this time the shore of Lake Chicago (Plate XXXV) extended from west of Wilmette south to Jefferson Park, Austin, Riverside and Lyons, and thence down the Desplaines Valley, below the line of the Glenwood beach. On the south side the beach follows pretty closely the Glenwood line east to a point just south of Palos Springs, thence southeast to near Thornton, from which point it runs east and northeast into northwestern Indiana and southwestern Michigan. Mt. Forest island and Blue Island were joined at this stage, forming a rather long, narrow piece of land, bent in the form of a bow. Washington Heights marks its eastern limit and Summit its northern limit. A hook and small bar were formed southeast of the former village. Extending from the northern point of this island, in a northwesterly direction, was a large bar which terminated in a strong hook (composed of three overlapping branches) bent to the south. This bar evidently partly enclosed a small bay[28] or lagoon, with marshy borders, which was of considerable extent and varied in depth from a few inches to ten feet. The crest of Lane's Island was just above the water, which rushed thru the Sag outlet in a stream from one to over two miles in width.

[25] See Goldthwait, Records of Extinct Lakes, p. 61, for an explanation of this "stoping" process.

[26] *Op. cit.*, p. 60.

[27] Goldthwait, The Desplaines Valley, pp. 54, 55.

[28] For convenience this may be called Summit Bay.

To the north the lake developed a large, distinct embayment (Plate XXXVI). From the shore line north of Wilmette (now cut away to the extent of a mile or more) a hook was formed by the southward drift. At about the same time an off-shore barrier of sand was formed which extended in a north and south line from Bowmanville to Evanston. It seems evident that this bar (the Rose Hill bar) was largely built under water during the Calumet stage, as only the crest is above the 35 foot contour. The pronounced bar and peninsula extending from Evanston southward was built up during the interval between the Calumet and Toleston stages on this off-shore barrier. During the Calumet stage there were evidently several breaks in the bar, which formed shallow water connections between the bay and the larger lake.

The west side of the barrier developed several pronounced hooks which indicate that wave and current action were strong. Besides several minor hooks and ridges, one large hook extended from Rogers Park into the lake in a northwesterly direction, for the distance of a mile. The dominant wind was evidently from the south or southwest, which caused the formation of this strong hook, as well as the bow-shaped curve of the termination of the barrier west of Bowmanville. As the town of Wilmette lies on the floor of this ancient embayment, it has been named Wilmette Bay.[29]

a. Life

It is probably true that the rising of the waters initiating the Calumet stage exterminated much of the biota occupying the lake during the Bowmanville stage, covering it with a layer of sand and gravel. That there was no life in the waters during the Calumet stage does not follow, however, and it is highly probable that the varied naiad fauna which took possession of Wilmette Bay invaded Lake Chicago sometime during the lowering of the lake from the Calumet (35 foot) to the Toleston (20 foot) level. In the bed of the Calumet-Sag channel the Unios lie directly upon the boulder pavement which forms the covering of the till, and these are covered by gravels which were laid down during the Toleston stage, mostly in the later part of this stage. These are considered in the discussion of the Toleston stage.

Leverett[30] and Goldthwait[31] have both stated that no evidences of life have been found in the Calumet beach. Those who have studied the recent beaches of the Great Lakes know that life is frequently absent from long stretches of beach, and when present at one time may be at another totally obliterated by the pounding of the waves and the moving of the sand. As a rule, fresh water beaches are poor preservers of the remains of life while quiet lagoons and bays are the best preservers, even the delicate wings of insects

[29] Goldthwait, Records of Extinct Lakes, p. 62.
[30] Pleistocene Features, p. 73.
[31] Records of Extinct Lakes, p. 63.

and the leaves of frail water plants being perfectly preserved. Even in the Toleston beach fossils are uncommon, tho they are abundant in the silts formed in protected localities during this stage.

b. Supposed Evidences of Marine Life

Alden[32] has reported the finding of certain marine mollusks and corals in the Calumet beach, near Chicago Lawn. These have been personally examined, as has also much additional material from other localities. Later investigation has shown this material to have been artificially introduced by the American Indians, and the localities at Chicago Lawn and Palos Springs may be safely cataloged as old camp sites. At Palos Springs, Mr. A. Scharf, an enthusiastic archaeologist, discovered a deposit of marine shells[33] *mixed with flint chips*. These were in the Glenwood beach, and, therefore, if the arguments advanced for the presence of marine conditions during the Calumet stage are used, the presence of these marine shells would lead to the hypothesis of a Glenwood sea separated by a low water stage of fresh water! Similar material has been found in other localities and the fact of their recent inclusion in these deposits thru man's agency cannot be questioned.

The presence of certain marine crustaceans in the Great Lakes[34] has suggested the possible occupancy of the lake basins by marine waters. These organisms, however, easily accustom themselves to fresh water and it is quite probable, if not certain, that they entered the lakes by way of the North Bay outlet, via the Ottawa river, during the Champlain submergence. The low temperature of the glacial waters would enable these creatures to become gradually accustomed to fresh water.[35]

D. THE TOLESTON STAGE

After a period, the duration of which is not known, the lake fell fifteen feet and built up a third set of shore lines from 20 to 25 feet above the present

[32] Geography of Chicago pp. 43-46; also Chicago Folio. See this volume page 14 for a discussion of this subject.

[33] Found 300 feet west of the post office.

[34] In Lake Superior	In Lake Michigan
Mysis relicta	*Mysis relicta*
Pontoporeia hoyi	*Pontoporeia hoyi*
In Lake Onatrio	" *filscornis*
Pontoporeia affinis	*Triglopsis thompsoni*
	" *stimpsoni*

[35] Smith, S. I., The Crustácea of the Fresh Waters of the United States. Rep. U. S. Fish Com., 1872-3, pp. 642-645, 1874.

Nicholson, A. Bull. Geol. Soc. Amer., X, p. 170.

Stimpson, W. On the Deep-water Fauna of Lake Michigan. Amer. Nat., IV, pp. 403-405, 1870.

lake level. The cause of this lowering of level was probably the cutting down of the outlet near Lockport.

At this stage (Plate XXXVII) the shore lines extended from Wilmette southward and southeastward to a point north of Garfield Park, thence southwestward past Hawthorne, joining the Calumet shore line below Lyons. On the south side of the lake the shore line ran parallel with the Calumet beach as far as Palos Springs; from here it extended eastward to Dalton and then formed a long, crescentic beach a mile or two north of the Little Calumet River, and joined the present shore line east of Millers, Indiana.

Mt. Forest Island was greatly increased in area by the lowering of the water, extending from Summit eastward to within a mile of Englewood, thence southeast to Auburn Park and Pullman, and south to a point a mile or so northwest of Dalton. The island was increased in size on its southern border, Lane's Island became a long and narrow piece of land, and the Sag outlet was reduced to a narrow stream from half a mile to a mile in width. Stony Island appeared above the water at this stage.

The Rose Hill bar (Plate XXXVIII) was largely built up at this stage to form a wide peninsula extending from Wilmette to Bowmanville, and an offshore barrier developed, extending from Rose Hill cemetery in a southeasterly direction to North Avenue, at the southern end of Lincoln Park. The enclosed bay was over ten miles in length and from one and a half to three miles in width. The Rose Hill bar was probably largely built up during the interval between the 35 and 20 foot stage, and previous to the formation of the Graceland barrier. This is made evident by the very strong character of the hook extending from the Rose Hill cemetery thru Bowmanville to the Chicago River. When the water reached the 20 foot level, or perhaps before this time, the Graceland bar was formed, as well as a secondary bar or beach extending from Evanston to Devon Avenue, and thence southward, joining the Graceland bar. Between this bar and the Rose Hill bar there was a long, very narrow lagoon, which later became a pond. Another pond developed to the north, extending from Church Street northward. The bed of the first long pond can easily be seen west of Clark Street, between this ridge and the higher Rose Hill bar, now known as Ridge Avenue. North of Rogers Park this lake bed is now cultivated by truck gardeners. The contours on the map of the Sanitary District suggest many irregular hooks which usually develop in such situations, where wind and current action are at work in comparatively shallow water.

a. Comparison with modern embayments

Wilmette Bay extended from Foster Avenue north to within a short distance south of Central Avenue, Evanston. At this stage it was shallow, the depth ranging from 20 feet at Foster Avenue to 2 feet at the head of the bay

south of Central Avenue. North of Devon Avenue the depth did not exceed 7 feet. It is conceivable that the points and spits of the shores developed hooks of greater or less size, which fluctuated with the violence of the waves. This ancient bay may be compared with Braddock's Bay, New York, which is a small body of water on the south shore of Lake Ontario, near Rochester. Braddock's Bay has a length of over a mile and a width of half to three quarters of a mile. Its depth does not exceed 9 feet, and in most places it is less than 5 feet in depth (Plate XXXIX).

A large portion of the basin in which Braddock's bay lies (especially the southern portion) is a vast marsh in which the water is from 6 to 18 inches in depth, and which is covered with such plants as *Typha latifolia*, *Sparganium eurycarpum*, *Sagittaria latifolia*, *Pontederia cordata*, and *Decodon verticillatus*. The water is more or less filled with such aquatic plants as *Chara*, *Lemna*, *Potamogeton*, *Scirpus*, *Nymphœa advena* and *Castalia odorata*. Several years ago careful measurements were made the length and width of the bay which indicate that the embayment is gradually filling up. Sand is rapidly being driven in by the waves, the two long sandy points at either end of the shore attesting the violence of this agency (Plates XL, XLI). The hooks are gradually extending and will eventually enclose all but a very small portion of the bay. The fauna is large and varied including sand-loving and swamp-loving animals.

b. Mollusk Fauna of Braddock's Bay

Elliptio complanatus
Anodonta marginata
" *grandis*
" *grandis benedictensis*
Lampsilis nasuta
" *radiata*
" *luteola*
" *luteola rosacea*
Sphaerium sulcatum
" *fabale*
Campeloma decisum
" *integrum*
Valvata obtusa (introduced)
" *tricarinata*
" *bicarinata perdepressa*
Somatogyrus subglobosus
Bythinia tentaculata
Amnicola emarginata
" *limosa*
" *lustrica*
Physa gyrina
" *ancillaria*
Ancylus parallelus
Segmentina armigera
Planorbis parvus
" *hirsutus*
" *antrosus*
" *campanulatus*
" *trivolvis*
Galba humilis modicella
" *obrussa*
" *palustris*
" *catascopium*
Pseudosuccinea columella
Lymnaea stagnalis appressa

It is of interest to compare this fauna with that of the ancient Wilmette Bay, which was doubtless physiographically similar, the difference being in the preponderance of the naiades in the latter deposit. During a late stage of Lake Iroquois, Braddock's Bay was a much larger body of water, comparable in both extent and depth with Wilmette Bay.

c. Life of the Toleston Stage

i. Wilmette Bay

During the Toleston stage (or possibly the latter part of the Calumet stage) a rich naiad fauna took possession of the deeper portion of the bay. These are of the heavy Mississippi River type of mussels; these animals usually live in water from 5 to 20 feet in depth, which fact accounts for their absence in the strata north of Devon Avenue, where the water was comparatively shallow. As this fauna lies directly upon the Calumet gravels, it is apparent that they appeared early in this stage. These mollusks were probably brot up by way of the Desplaines outlet (in the glochidium stage) thru the agency of fish. That the fauna was a rich one is attested not only by the number of species represented, but notably by the large number of individuals, the beds in many places being as thick as those now found in the Mississippi River in certain favorable spots.

The molluscan fauna of this stage is listed below:

Fusconaja undata
Crenodonta undulata
" *peruviana*
Quadrula pustulosa
" *lachrymosa*
Rotundaria tuberculata
Pleurobema coccineum magnalacustris
Elliptio crassidens
" *gibbosus*
Lasmigona costata
Obliquaria reflexa
Amygdalonajas elegans
Proptera alata
Eurynia ellipsiformis
" *recta*
Lampsilis luteola
" *ventricosa*
Sphaerium rhomboideum
" *sulcatum*
" *flavum*
" *striatinum*
Pisidium compressum
" *scutellatum*
" *virginicum*
" *variabile*
" *affine*
" *walkeri*
" *politum*
" *splendidulum*
" *pauperculum*
Campeloma integrum
" *subsolidum*
Goniobasis livescens
Amnicola limosa
" *letsoni*

35 species are represented of which 30 are bivalves. Three of the species are especially notable. *Unio* (*Elliptio*) *crassidens* does not now live in this region, its nearest records being Utica, La Salle County, 80 miles southwest and Carroll County, 125 miles west of Chicago. That this species attained a more northern range during the Toleston (or an earlier) stage is evidenced by the discovery of a specimen some years ago, by Mr. George Wagner,[36] in deposits near Green Bay, Wisconsin. In view of the northern extension of the fossil form, it may be of interest to tabulate the northern limit of the distribution of the recent form, and to compare it with the Green Bay fossil record.[37]

[36] Nautilus, XVIII, pp. 97-100, 1905.

[37] These records are taken from recent reports.

South of Green Bay record

Wisconsin, between Prairie du Chien and De Soto[38]	80 miles
Minnesota, not recorded	
Iowa, Lansing[39]	80 "
Michigan, not recorded	
Illinois, Utica, LaSalle Co.[40]	220 "
Ohio, Scioto River[41]	260 "
Indiana, Tippecanoe[42]	230 "

It is interesting to note that recent *crassidens* is found only in the Mississippi River drainage.[43]

It has been thot that the presence of this species so far north might indicate a period during which a warmer climate than the present prevailed. The accompanying species, however, are mostly of northern distribution, and this assumption may rest upon insufficient grounds; it may be a case in which the mollusk was not able to adapt itself to a new invironment and so became extinct so far as these regions are concerned. The lowering of the water, changing the environment from a bay to a marsh may have caused the extinction of the Chicago colonies. The Green Bay fauna evidently migrated up the Mississippi and Wisconsin rivers and thence thru an embayment of glacial Lake Chicago, the precursor of the present Green Bay.

Pleurobema coccineum magnalacustris is also of special interest. It is greatly inflated and differs quite markedly from the typical form of *coccineum.* Simpson remarks that it "seems almost entitled to specific rank." It is found in the St. Lawrence drainage, particularly near Niagara Falls, which is the type locality. The typical form of *coccineum* is not represented in the Chicago deposits, but the variety is one of the most abundant of naiads next to *crassidens* and *pustulosa.* The shells mentioned by Miss Letson from the gravels of Niagara Falls, are probably this race.[44] As it is not now found in the Mississippi drainage, it must have become extinct in this region during one of the stages of Lake Chicago. Typical *coccineum* is rare or wanting in the St. Lawrence drainage; the race *magnalacustris* seems to have migrated via the Chicago outlet to the vicinity of Niagara Falls where it flourished thru several lake stages, but finally became extinct in all but a few localities. Recent specimens have been seen[45] from the Detroit River and the Grand River, Michigan,

[38] Chadwick, Bull. Wis. Nat. Hist. Soc., IV, p. 95, 1906.

[39] Museum record.

[40] Baker, Bull. Ill. State Lab. Nat. Hist., VII, p. 77, 1906.

[41] Sterki, Proc. Ohio Acad. Sci., IV, p. 392, 1907.

[42] Daniels, 27th An. Rep. Dept. Geol., Indiana, p. 650, 1902.

[43] The deposits in and about Green Bay should be carefully examined, for they doubtless contain much material bearing on the question of life distribution during postglacial times.

[44] Geology of Niagara Falls, p. 252, figure 190.

[45] Walker collection.

clearly indicating the route by which this race reached the Niagara Falls locality.

The presence of *Amnicola letsoni* in these deposits is also of interest. This little species was first recorded from the gravel deposits on Goat Island, Niagara Falls,[46] in strata laid down by the waters of Lake Algonquin. The Toleston stratum is earlier, contemporaneous in fact with early Lake Algonquin, and it is probable that the species reached the Goat Island locality by way of the Chicago outlet. *Letsoni* was at first thot to be extinct, but has since been found "recent, thó dead, washed up on the shore of Lake Erie[47] in Monroe County, Michigan. I have also a single dead specimen from the drift of the Raisin River at Dundee, Michigan." *Letsoni*, like *Pleurobema coccineum magnalacustris*, may be a species approaching extinction. It was apparently abundant during the Toleston stage of Lake Chicago and persisted at Niagara Falls until a comparatively recent date.

It is a matter of great interest that these two distinctive species originally discovered (in a fossil condition) at Niagara Falls, should also be found in these earlier deposits of glacial Lake Chicago, clearly showing that the migration into the englaciated territory was by way of the Chicago outlet. The Fort Wayne outlet of Lake Maumee may also have been a factor in repopulating the Lake Erie region, as suggested by Walker,[48] but it must be remembered that this outlet persisted for but a comparatively short period (until the formation of Lake Whittlesey) while the Chicago outlet persisted until almost the close of the lake stages (until late in the Nipissing stage). The evidence afforded by the material under discussion favors a migration for the most part by way of the Chicago outlet.

A comparison of the molluscan faunas of the Niagara Falls and the Chicago outlet regions shows that of the 33 species found in the Toleston deposits, only 10 are found in the Goat Island gravels, 21 of the latter being different species. The gastropods are more nearly related to the subsequent stage (of Lake Algonquin).

No insect remains have been seen from these deposits, but borers have been reported from the fossil oaks at Evanston.[49]

ii. Toleston Deposits in or near the Outlet

In the Sag outlet at a point where the Calumet–Sag channel crosses 92nd Avenue, the fauna listed below lies just above the boulder pavement of the till. In this deposit the absence of a fauna referable to the previous low water stage is noteworthy. If such strata were laid down they were destroyed by the

[46] Letson, Bull. Buffalo Soc. Nat. Hist., p. 241, fig. 165.
[47] Bryant Walker in letter.
[48] Nautilus, XXVII, p. 58 and ante.
[49] Higley and Raddin, page XV.

cutting down of the outlet during the subsequent rise of the water which initiated the Calumet stage. The presence of *Elliptio crassidens* and *Pleurobema coccineum magnalacustris* is to be noted.

Elliptio crassidens	*Campeloma integrum*
" *gibbosus*	" *integrum obesum*
Pleurobema coccineum magnalacustris	*Goniobasis livescens depygis*
Crenodonta undulata	*Valvata tricarinata*
Fusconaja undata	*Amnicola limosa*
Eurynia recta	" *lustrica*
Lampsilis ventricosa	*Physa warreniana*
Pisidium virginicum	*Planorbis deflectus*

At a point where Austin Avenue crosses the Ogden ditch a silt bed was observed which contained:

Fusconaja rubiginosa	*Pleurobema coccineum magnalacustris*
Rotundaria tuberculata	*Elliptio gibbosus*
	Eurynia recta

In the above lists *Goniobasis livescens depygis* and *Fusconaja solida* are not found in the deposits of the north shore channel.

iii. Vertebrate Life

Birds

The biota of this stage included vertebrates as well as invertebrates and plants. In a deposit of silt between two beds of naiads the humerus of a Merganser (*Mergus serrator*) was found. It was identified by Dr. R. W. Shufeldt.

Mammals

The remains of the higher vertebrate animals have been found in the Chicago area, some of which may be referred to this stage of the lake history. Many records are from strata which cannot be definitely correlated, but as it is believed that these animals roamed the shores of the ancient lakes until a late period, they are all here included.

Mammut americanum

Wicker Park, near Milwaukee Avenue, covered by 13 feet of silt. Jaw, teeth, and other bones[49]

Middle beach, Evanston, on C. & N. W. Railroad. Fossil ivory[49]

Lake County, Indiana[50]

Berrien County, Michigan[51]

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[50] Blatchley, 1897, p. 89.

[51] Walker, Nautilus, XI, p. 121.

Elephas primigenius (or *columbi?*)
Lake County, Indiana[51]
Haas' gravel pit, Oak Park[52]
Elephas columbi
Chicago Heights, in creek bank, 18 or 20 feet below surface, in Wallace Creek.[53]
Odocoileus virginianus
Toleston beach, Evanston. Pelvic bones.[54]
Toleston beach, Evanston. Femur.[55]

E. THE SAG LOW WATER STAGE[56]

(*Kirkfield Stage of Lake Algonquin*)

Previous to the Toleston stage the glacial lakes consisted of local bodies of water, which grew in size as the ice melted. Thus we have lakes Upham and Duluth in the Superior basin; lakes Maumee, Saginaw, Arkona, Wayne Whittlesey, Warren, and Lundy in the Huron-Erie basin; and Lake Chicago in the Michigan basin. During the formation of these lakes the outlet was mostly by way of Chicago to the Gulf of Mexico. Lake Erie began as a small body of water in the eastern end of the Erie basin its outlet being into Lake Iroquois (in the Ontario basin) which emptied into the Atlantic Ocean via the Mohawk and Hudson rivers.

The ice sheet gradually withdrew farther toward the northeast, causing the Superior, Huron, and Michigan basins to unite and form a single body of water known as Lake Algonquin. During the life of Lake Iroquois the ice uncovered the Trent Valley in Ontario which provided a lower outlet for the waters of Lake Algonquin, which flowed thru this valley past Kirkfield into Lake Iroquois. This change of outlet at first caused a lowering of the water in the Chicago region, in many localities a land surface appearing. This condition is attested by the oxidized character of some of the silt beds above the Unio deposit and also by the presence of peat deposits. Uplift in the region of the Trent outlet eventually brot the lake up to a level high enough to discharge again thru the Chicago and St. Clair outlets. The water in the Chicago basin probably was raised to the Toleston level (20 feet), forming the Hammond stage.[57]

[52] Leverett, 1897, p. 71.
[53] Collected by Mr. James H. Knapp.
[54] Higley and Raddin, p. XIV.
[55] Leverett, 1888, p. 188.
[56] It seems desirable that the different stages of Lake Chicago and its successors should receive local names, even when the stage is a part of the Great Lake system, for the convenience of students of postglacial life. As this low water stage is shown to the best advantage in the beds of the old Sag outlet, this name is here suggested. See footnote under Hammond stage.
[57] This height is given by Leverett (12th An. Rep. Mich. Acad. Sci., p. 36). Goldthwait (Bull. Ill. Geol. Surv. VII, p. 64; XI, p. 56) refers the Algonquin level to the 12-14 foot beaches. The evidence in the north shore channel and elsewhere is in favor of the 20 feet return, as suggested by Leverett.

The Toleston stage of the Chicago basin is apparently correlative with the early part of Lake Algonquin when the waters of the Superior, Huron, and Michigan basins had united; the low water stage occurring during the Kirkfield stage of this episode. The low water period is indicated by beds of peat in the upper part of Wilmette Bay and by thin beds of sand in the lower part. Near Devon Avenue a bed of peat 38 inches thick occurs, interstratified with very thin beds of fine sand, indicating shallowing conditions. In the Sag outlet this stage is represented by several feet of fine gravel and sand, containing pockets of fine gravel mixed with wood and shells. These deposits, with their biotic contents, are indicated below.

a. *The North Shore Channel* (*Wilmette Bay*)

In the north shore channel the strata above the Unio bed consist of silt or sandy silt, capped by a bed of peat. The biota is characteristic of shallow water; the upper portion of this deposit is interstratified with sand indicating shallowing conditions and the life in these upper strata embraces more typical species of this condition than do those below. Wilmette Bay at this time was probably similar to a portion of Braddock's Bay, New York, where the water is from 5 to 9 feet in depth (Plate XLII). The fauna and flora of the shallowing bay is listed below.

Plants

Potamogeton species
Hypnum species
Najas species
Carex species
Chara species
Picea canadensis
" *mariana*
Quercus species

Animals (Mollusks)

Rotundaria tuberculata
Quadrula pustulosa
Crenodonta peruviana
Elliptio gibbosus
Anodonta grandis
" *grandis footiana*
Lampsilis luteola
Sphaerium rhomboideum
" *solidulum*
" *flavum*
" *stamineum wisconsinensis*
" *acuminatum*
" *striatinum*
" *sulcatum*
Musculium secure
" *transversum*
Pisidium affine
" *compressum*
" *compressum lævigatum*
Pisidium scutellatum
" *walkeri*
" *abditum?*
Campeloma integrum
" *subsolidum*
Goniobasis livescens
Valvata tricarinata
Amnicola limosa
" *limosa porata*
" *lustrica*
" *emarginata*
Somatogyrus subglobosus
Physa warreniana
" *integra*
" *gyrina*
Ancylus fuscus
" *parallelus*
Planorbis antrosus
" *campanulatus*

Pisidium kirklandi
" *noveboracense*
" *pauperculum*
" *politum*
" *politum decorum*
" *sargenti*
" *splendidulum*
" *variabile*
" *virginicum*

Planorbis trivolvis
" *deflectus*
" *exacuous*
" *parvus*
Segmentina armigera
Galba obrussa
" *palustris*
" *reflexa*
Lymnaea stagnalis appressa

Pisces

Amia calva
Lepomis species
Silurid or *Cyprinoid*

The fish are represented by portions of skulls, scales, and isolated bones. In the case of *Amia*, however, a single rather complete skeleton was found.

It will be observed that the molluscan fauna of the bay was rich and varied, consisting of species representing all of the important families of fresh water shells. Compared with the preceding stage the decrease in the Unionidæ is notable (from 17 to 7 species) as is also the increase in gastropods (from 5 to 25 species). The larger number of Pisidia is also noteworthy (from 9 to 15 species). It is seen at once, by a comparison of this list with that of the preceding stage, that in the stage under consideration the majority of the species are of shallow water types—*Lymnaea*, *Planorbis*, *Physa*, *Ancylus*, *Anodonta*, *Pisidium*—indicating clearly a change of environment, i.e., from deeper water with sandy bottom, to shallower water with muddy or silty bottom. The fish remains were associated with the plant *Chara*, indicative of shallow water. Wilmette Bay at this stage had become so shallow that the naiads could live only in a small portion near the center and toward the deeper water north of Foster Avenue, where the bay narrowed and opened into the larger bay south of Foster Avenue and west of the Graceland bar.

b. *The Calumet–Sag Channel* (*Sag Outlet*)

A bed of sand and gravel in this channel (at 92nd Street) is confidently believed to represent this low water stage. It is over four feet in thickness and contains drift wood and dead shells such as may be seen in shallow water or on a gravelly beach. A varied fauna is preserved in these gravels, as noted below.

Quadrula pustulosa
Fusconaja undata
Sphaerium acuminatum
" *occidentale*
Pisidium virginicum
" *compressum*
" *splendidulum*
" *medianum*

Valvata tricarinata
" *tricarinata simplex*
" *tricarinata confusa*
" *tricarinata unicarinata*
Physa warreniana
" *integra*
" *walkeri*
Planorbis antrosus

Pisidium fallax	*Planorbis campanulatus*
Campeloma integrum obesum	" *deflectus*
Goniobasis livescens depygis	" *parvus*
Amnicola limosa	*Segmentina armigera*
" *lustrica*	*Galba obrussa exigua*
	" *obrussa decampi*
	" *palustris*
	" *woodruffi*

c. The Desplaines Valley

In the Valley of the Desplaines River near Lemont a bed of silt and marl overlies the Niagara limestone, which contains molluscan species similar to those in the Wilmette Bay deposits. The location of this deposit is near the 595 foot contour and the mollusks evidently lived along the edge of the old outlet in shallow water, out of reach of any strong currents. The level of the lake at this time was probably too low to allow of much of a discharge thru the Chicago outlet and the valley may have been simply a long narrow bay during this low water period. The water was evidently loaded with fine sediment, a deposit nearer the center of the valley, which is believed to be correlative with this episode, being 58 inches in thickness. The life of the strata at Lemont is as noted below.

Pisidium compressum	*Planorbis antrosus*
" *mainense*	" *campanulatus*
" *splendidulum*	" *trivolvis*
Valvata tricarinata	" *deflectus*
Amnicola limosa	" *exacuous*
" *lustrica*	" *parvus*
Goniobasis livescens	*Galba reflexa*
Campeloma integrum	" *obrussa*
Physa warreniana	*Lymnaea stagnalis appressa*
" *integra*	*Succinea avara*
Segmentina armigera	

A peat bed above the silt deposit contains biotic remains indicating a still greater shallowing of the water, perhaps preceding a temporary land surface. The fauna of this bed includes:

Mollusca

Valvata tricarinata	*Planorbis parvus*
Amnicola limosa	" *trivolvis*
" *lustrica*	*Galba obrussa*
Physa gyrina	" *obrussa decampi*
Planorbis exacuous	" *reflexa*
Segmentina armigera	*Lymnaea stagnalis appressa*

Vertebrates

Odocoileus virginianus. Skull
Fiber zibethicus. Skull

d. Windsor Park, South Chicago

At the corner of 75th Street and Jeffrey Avenue a deposit of sand and gravel occurs, five feet below the surface, which contains fourteen species of mollusks, as noted below.

Sphaerium striatinum	*Valvata bicarinata perdepressa*
Pisidium virginicum	*Goniobasis livescens*
" *compressum confertum?*	*Amnicola lustrica*
" *superius*	" *emarginata*
" *mainense* (related to, but distinct)	" *letsoni*
Galba catascopium	*Somatogyrus integer*

The bedrock (limestone) outcrops nearby on Kingston Avenue, and is 585 feet above sea level or 5 feet above Lake Michigan. The shells were evidently washed behind this rock barrier during the low water stage. The presence of *Amnicola letsoni* is noteworthy.

e. Evanston

In Marcy's section of the Toleston beach, in the ridge which crosses the University campus, a number of shells were found in peat and silt deposits, beneath heavy beds of beach sand and gravel believed to be of Hammond age. From this, and from an equivalent deposit in a section more recently studied by the writer fourteen species have been identified.

Sphaerium sulcatum	*Ancylus species*
Pisidium dubium (=*virginicum*).	*Planorbis trivolvis*
Goniobasis livescens	" *campanulatus*
Pleurocera elevatum	" *parvus*
Amnicola limosa	*Galba palustris*
" *lustrica*	" *reflexa*
Physa warreniana	" *caperata*

Naiad shells were observed but too much decomposed to permit of identification. *Anodonta grandis footiana* was probably represented. An oak, named *Quercus marcyana* by Prof. Penhallow, was obtained in considerable quantity from the sand deposit above the peat bed (see 4 and 5 in I of Plate IV).

F. THE HAMMOND STAGE[58]

Differential uplift in the region of the Trent Valley eventually raised the height of the Kirkfield outlet until the waters again discharged thru the Chicago

[58] In a previous paper (Baker, Trans. Ill. Acad. Sci., IV, pp. 109-116) the two last stages of the postglacial lake were designated "Middle Toleston" and "Lower Toleston." Stratigraphically this produces a geological absurdity, Lower Toleston being placed above Upper Toleston. These terms are correct for the lake stages but are not correct for geological strata. For this reason the term Hammond is here substituted for Middle Toleston and Englewood for Lower Toleston, these names being quite as appropriate as the terms Glenwood, Calumet, and Toleston.

and St. Clair outlets. At first nearly all of the discharge was by way of Chicago, but as that outlet was controlled by a rock sill, the greater outflow was shifted to the St. Clair outlet, that being in till which was cut thru in a relatively short time. Of the Chicago outlet at this time Taylor[59] says: "The time of this large-volume discharge at Chicago was the time when the Toleston beach was made, and if there was a beach of Lake Chicago there before and controlled by the same sill, it must have been overwhelmed and worked over entirely by Lake Algonquin waters." This is probably just what did happen, the first or Toleston beach being formed when the water dropped from the 35 (Calumet) to the 20 (Toleston) level; the beach usually called Toleston is evidently what is here designated as Hammond and was formed during the large-volume discharge following the low water or Kirkfield stage. Lake Chicago at this time had about the same outline as during the Toleston stage. Mollusks and other animals survived the low water period, and an extensive biota is preserved in the strata of this second high water stage.

a. *Wilmette Bay (North Shore Channel)*

Marl and silt beds in this channel south of Devon Avenue contain a varied biota referable to the Hammond stage.

Plants

Potamogeton species	*Najas* species
Scirpus species	*Nymphaea advena*
Carex species	*Typha latifolia*

Animals

Sphaerium levissimum	*Campeloma integrum*
" *stamineum*	*Valvata tricarinata*
" *rhomboideum*	*Amnicola limosa*
" *flavum*	" *lustrica*
" *sulcatum*	*Physa warreniana*
" *solidulum*	" *integra*
" *striatinum*	*Planorbis antrosus*
Pisidium compressum	" *campanulatus*
" *affine*	" *trivolvis*
" *noveboracense*	" *deflectus*
" *splendidulum*	" *parvus*
" *variabile*	*Galba reflexa*
" *virginicum*	*Lymnaea stagnalis appressa*

Wilmette Bay had about the same outline at this time as during the Toleston stage (see Plate XXXVIII). North of Devon Avenue the bay was shallow with swampy shores. The water contained such plants as *Chara* and *Potamogeton*, and the shores were probably lined with *Typha*. This shallow, marshy portion was over four miles long and from one to two miles wide. This

[59] Smith. Rep., 1912, p. 319.

part of Wilmette Bay must have been comparable to the southern portion of Braddock's Bay, especially that part bordering the shores (see map Plate XXXIX, and Plate XLIII). This habitat afforded an ideal home for shallow water mollusks, as indicated by the subjoined list.

Sphaerium stamineum	*Planorbis parvus*
" *emarginatum*	*Segmentina armigera*
Musculium truncatum	*Galba caperata*
Pisidium affine	" *reflexa*
Physa gyrina	*Succinea retusa*
Planorbis trivolvis	" *avara*
	Cambarus blandingi acutus

The crayfish is a pond or lake form, not a river form, and is the only representative of the subgenus *Cambarus* living in this territory (vide Ortmann). The remains of this crayfish were numerous, but always poorly preserved, consisting of a broken carapace, several chelæ, and fragmentary legs. This crustacean lives among vegetation, in woodland swamps, shallow ponds and pools, burrowing occasionally in the black muck soil.

Dr. A. E. Ortmann, to whom specimens were submitted, remarks upon the material as follows: "The specimen, of course is awfully poor; but as it happens, one very important character is seen: the corpulatory hooks of the ischiopodites of the 3rd and 4th peraeopod of the left side, are distinctly seen. Species with this character (subgenus *Cambarus*) are all southern, with the exception of *C. blandingi*, and this excludes all other species found at the present time in your region. After ascertaining this, and also ascertaining that the specimen is, according to these hooks, a male of medium size in the second form (impotent, not able to copulate), I compared it with specimens of the living form, *C. blandingi*, of the same size and condition, and found complete agreement. The fortunate circumstance that this is a male, and that it shows the characteristic hooks of the ischiopodite is all-important, and I do not hesitate at all, to assign it to the species as given above."

b. Sag Outlet (Calumet–Sag Channel)

In the Sag outlet a deposit of fine sand overlying the gravel deposit evidently represents the deeper water of the Hammond stage. Eleven species of mollusks have been noted from this stratum.

Elliptio gibbosus	*Valvata tricarinata*
Sphaerium acuminatum	*Physa integra*
Pisidium virginicum	*Planorbis parvus*
Goniobasis livescens	*Galba obrussa*
Amnicola limosa	" *palustris*
" *lustrica*	

Four feet of fine, almost impalpable clay cover this sand deposit, indicating that the water at this later stage was heavily filled with sediment. No life was observed in this stratum.

c. Near Calumet Lake

South of Calumet Lake, near 130th Street, east of the Michigan Central Railway tracks, a number of mollusks were found beneath Indian graves. They are believed to be referable to the Hammond stage. Six species are represented.

Fusconaja undata	*Eurynia recta*
Quadrula pustulosa	*Lampsilis ventricosa*
Elliptio gibbosus	*Goniobasis livescens*

G. LOW WATER STAGE—THE CHAMPLAIN SUBMERGENCE

The continued recession of the ice to the northeast eventually uncovered a low pass thru Lake Nipissing and the Ottawa Valley and the lake waters fell upwards of 60 feet,[60] forming a three-lake condition. At the same time the land to the east was submerged and the sea entered the St. Lawrence basin, forming two arms, the southern arm extending well into the Ontario basin and the northern arm entering the Ottawa Valley. Oxidized silt beds overlying the deposits of the Hammond stage are believed to represent this low water stage, at which time all of the land covered by the lake waters was made dry. As no evidence of terrestrial (or other) life have been found in this stratum it is to be presumed that the low water stage did not endure long enough for a fauna and flora to develop or migrate from the south.

H. THE ENGLEWOOD STAGE[61]

Continued uplift in the northern portion of the Nipissing outlet raised the level of the lakes until they again overflowed southward thru the St. Clair River, producing a condition known as the two-outlet stage. The lakes at this stage are also known as the Nipissing Great Lakes, the area covered being but little greater than that of the present Great Lakes. In the Chicago region the waters rose to about twelve feet above the present level. The shore lines of this stage "are characterized by an exceptionally strong development of cut bluffs and terraces, rather than by beach ridges. In this manner they express the vigorous encroachment of a lake which was rising upon its shores."[62]

During the Englewood stage (Plate XLIV) the shores of the lake differed little in position from those of the two preceding stages, except in the northern region. Wilmette Bay (Plate XLV) became much smaller; the Graceland

[60] Goldthwait (Records of Extinct Lakes, p. 66) suggests a sea-level stage.

[61] See foot-note page 90.

[62] Goldthwait, Records of Extinct Lakes, p. 67.

barrier became a bar varying in width from one-half to nearly two miles. From North Avenue to Foster Avenue the bay had a length of nearly five miles and a maximum width of a mile and a half. From Foster Avenue the bay extended northward as a narrow bayou less than a quarter of a mile wide; near Lincoln Avenue it spread out, forming two arms, and becoming a little over half a mile wide. The total extension of the bay north of Foster Avenue was a trifle over two miles. It varied from 4 to 12 feet in depth. The character of the deposits, as well as the life contained therein, show that the bay was for the most part shallow and its waters quiet. It was doubtless bordered by cat-tails, rushes, and reeds, and the shallow waters are known to have contained *Chara*, *Potamogeton*, and other aquatic vegetation.

Sometime during the Englewood stage a long bar was formed which extended from the southern end of the Graceland bar, at the south end of Lincoln Park, to the Hammond shore line near South Englewood, passing east of Englewood and thru Auburn Park (Plate XLIV). This bar completely shut in the bay north of Mt. Forest island, producing a huge marsh, similar to that now existing in the Sag region near Worth.

a. *Life of Wilmette Bay*

The mollusks which have been found in these deposits are suggestive of a shallow-water, marsh-bordered bay, the Valvatas and Amnicolas occupying the deeper parts and the small bivalves and the fresh water pulmonates living in the shallower portions near the shore. Fourteen species occur in these deposits, as shown below:

Plants

Potamogeton and *Najas* were common plants judging by the abundance of their remains.

Animals

Sphaerium sulcatum	*Physa integra*
" *stamineum*	" *gyrina*
" *solidulum*	*Planorbis antrosus*
Musculium transversum	" *campanulatus*
Pisidium compressum	" *trivolvis*
" *variabile*	" *parvus*
Amnicola limosa	*Galba palustris*
" *limosa porata*	" *caperata*
Valvata tricarinata	

The borings of crayfish were very numerous in this deposit, attesting the presence of these crustaceans.

b. *The Sag Outlet*

In the Sag channel a bed of peaty clay lies between a clay and a peat deposit and is believed to represent the bottom of the Sag outlet at the time of the Nipissing (transition) stage. It is probable that but little water flowed thru

the Chicago outlet at this time, this region being for the most part a quiet bay. Thirteen species of mollusks, an insect or two, and a few bones of fish were obtained from these deposits. These are noted below.

Mollusks

Anodonta species	*Planorbis exacuous*
Valvata tricarinata	" *parvus*
Amnicola limosa	*Ancylus parallelus*
" *lustrica*	*Galba palustris*
Physa warreniana	" *reflexa*
Planorbis campanulatus	*Lymnaea stagnalis appressa*
" *antrosus*	

Insects

Donacia proxima	*Coleoptera*, punctostriate elytron

Fish

Fragments and small bones.

The insects were referred to Prof H. F. Wickham, Iowa State University, Iowa City, Iowa, who writes as follows concerning the *Donacia:*

"The specimen is a fragment showing the base, part of the humeral and sutural regions and a portion of the disk of the left elytron, with colors well preserved, the wing-cover being blue-black over the disk and bright metallic green about the humerus. The sculpture is remarkably clearly exhibited, agreeing even in minute detail with recent specimens of *D. proxima* in the size, shape, arrangement and distinctness of the punctures, the lack of interstitial rugosities on the inner half of the elytral disk and the presence of fine transverse wrinkles in the humeral region. *Donacia proxima* is one of the most characteristically colored and sculptured of all the North American forms and is pretty easily recognized by those features alone. There is no reason to doubt that the fossil is specifically the same as the modern specimens with which it has been compared.

"*Donacia proxima* is now classified as a race or variety of *D. cincticornis* Newm. It occurs in Canada from Vancouver Island to Newfoundland as well as in California, Oregon, Idaho, Iowa, Wisconsin, Indiana Pennsylvania, New York, New Hampshire and Massachusetts, on the leaves of water plants. No special conclusions as to climate can be drawn from its presence as a fossil.

"In this connection, it is interesting to note that the genus is well represented in fossil condition, about thirty species being noticed or described from Tertiary and Pleistocene beds. The habits of the insects and their hard integuments combine to render their preservation more than usually likely."

I. THE PRESENT GREAT LAKES

Following the Nipissing stage the lake waters were gradually lowered by the cutting down of the St. Clair outlet. This gradual lowering of the lake

waters resulted in the formation of the broad sand terrace and dune ridges north of Waukegan, near Rogers Park, and in other places. During the recession of the lake a series of small bars and beaches were built up east of the Englewood barrier: particularly large beaches were developed in the neighborhood of Wolf Lake. Minor beachlets to the number of a hundred or more were formed along the south shore of the lake, in Indiana. Between these beachlets may now be found, particularly in the spring of the year, sloughs of greater or less extent.

The fauna of the Englewood stage, as the waters fell sought refuge in the small sloughs, in the small lakes (Calumet, Wolf, George, Hyde) and in the rivers. Doubtless other species have migrated northward and mixed with the fauna of the last postglacial stage. The present fauna is rich and varied as indicated in the table which follows:[63]

a. List of Mollusca Now Living in the Waters of the Ancient Lake Chicago Basin

		Recent			
	Post-Glacial[64]	Lake Micnigan	Small lakes	Rivers	Sloughs; swamps
Fusconaja undata	x			x	
" *rubiginosa*	x			x	
Crenodonta peruviana	x			x	
" *undulata*	x		x	x	
Quadrula pustulosa	x			x	
" *lachrymosa*	x			x	
Rotundaria tuberculata	x			x	
Pleurobema coccineum				x	
Pleurobema coccineum magnalacustris	x				
Elliptio gibbosus	x		x	x	
" *gibbosus delicatus*				x	
" *crassidens*	x				
Lasmigona compressa				x	
" *costata*	x			x	
" *complanata*				x	
Anodonta imbecilis				x	
" *grandis*	x		x	x	x
" *grandis footiana*	x		x	x	x
Anodontoides ferussacianus				x	
" *ferussacianus subcylindraceus*			x	x	
Alasmidonta marginata			x	x	
" *calceola*	x	x	x	x	

[63] Only the aquatic forms are listed.

[64] These occur in the strata of glacial Lake Chicago.

		Recent			
	Post-Glacial[64]	Lake Michigan	Small lakes	Rivers	Sloughs; swamps
Strophitus edentulus				x	
" *pavonius*		x	x	x	
Obliquaria reflexa	x			x	
Nephronajas ligamentina				x	
Amygdalonajas elegans	x			x	
" *donaciformis*				x	
Paraptera gracilis				x	
Proptera alata	x			x	
Eurynia parva				x	
" *ellipsiformis*	x			x	
" *recta*	x			x	
" *iris*	x		x	x	
Lampsilis luteola	x	x	x	x	
" *ventricosa*	x			x	
" *multiradiata*			x		
Sphaerium striatinum	x		x	x	
" *acuminatum*	x	x			
" *stamineum*	x		x	x	
" *stamineum wisconsinensis*	x				
" *sulcatum*	x		x	x	
" *solidulum*	x	x			
" *fabale*		x			
" *flavum*	x				
" *occidentale*	x		x		x
" *levissimum*	x				
" *rhomboideum*	x		x		
" *emarginatum*	x				
Musculium partumeium			x	x	x
" *truncatum*	x			x	x
" *secure*	x		x	x	x
" *transversum*	x			x	x
Pisidium[65] *abditum*	x		x	x	
" *abyssorum*		x			
" *adamsi affine*	x				
" *compressum*	x	x	x		
" *compressum confertum*	x				
" *compressum laevigatum*	x		x		
" *compressum rostrata*		x			
" *cruciatum*				x	
" *fallax*	x			x	
" *handwerki*				x	

[65] It will be noted that there are a number of Pisidia from the fossil deposits which have not yet been found in the recent fauna.

	Post-Glacial[64]	Recent			
		Lake Michigan	Small lakes	Rivers	Sloughs; swamps
Pisidium idahoense	x	x			
" *kirklandi*	x		x		
" *medianum*	x		x		
" *mainense*	x				
" *neglectum corpulentum*				x	
" *noveboracense*	x		x		
" *noveboracense elevata*				x	
" *peralta*		x	x	x	
" *politum*	x			x	
" *politum decorum*	x				
" *pauperculum*	x				
" *punctatum*				x	
" *punctatum simplex*				x	
" *roperi*				x	
" *sargenti*	x		x		
" *scutellatum*	x	x	x	x	
" *splendidulum*	x		x	x	
" *superius*	x				
" *tenuissimum*	x		x		
" *variabile*	x	x	x	x	
" *virginicum*	x	x	x	x	
" *walkeri*	x			x	
Vivipara contectoides			x		
Campeloma decisum			x	x	
" *integrum*	x		x	x	
" *integrum obesum*	x		x	x	
" *rufum*			x	x	
" *subsolidum*	x		x	x	
" *subsolidum exilis*				x	
Valvata tricarinata	x	x	x	x	
" *tricarinata simplex*	x				
" *tricarinata confusa*	x	x			
" *tricarinata unicarinata*	x				
" *bicarinata*		x			
" *bicarinata perdepressa*	x	x			
" *bicarinata normalis*		x		x	
" *lewisii*		x			
Bythinia tentaculata		x			
Amnicola limosa	x	x	x	x	
" *limosa parva*			x		
" *limosa porata*	x	x	x	x	
" *lustrica*	x	x	x	x	
" *emarginata*	x	x		x	

	Post-Glacial[64]	Recent			
		Lake Michigan	Small lakes	Rivers	Sloughs; swamps
Amnicola cincinnatiensis		x		x	
" *letsoni*	x				
Somatogyrus subglobosus	x	x	x		
" *integer*	x	x			
Paludestrina nickliniana			x		
Pomatiopsis lapidaria			x	x	
Pleurocera elevatum	x	x	x	x	
" *elevatum lewisii*				x	
" *subulare*			x	x	
Goniobasis livescens	x	x	x	x	
" *depygis*	x			x	
Physa warreniana	x	x	x		
" *integra*	x	x		x	
" *walkeri*	x			x	
" *gyrina*	x				x
" *heterostropha*		x	x		
Aplexa hypnorum					x
Ancylus parallelus	x		x		x
" *fuscus*	x		x	x	
" *rivularis*				x	
" *tardus*					x
Planorbis antrosus	x		x	x	
" *campanulatus*	x		x	x	
" *truncatus*			x	x	
" *trivolvis*	x		x	x	x
" *parvus*	x		x	x	x
" *exacuous*	x		x	x	x
" *deflectus*	x		x	x	x
Segmentina armigera	x		x	x	x
Lymnaea stagnalis appressa	x		x	x	
Pseudosuccinea columella			x		
" *columella chalybea*			x		
Galba caperata	x		x	x	x
" *parva*			x	x	
" *parva sterkii*					x
" *humilis modicella*			x	x	x
" *obrussa*	x		x	x	x
" *obrussa exigua*	x		x	x	x
" *obrussa decampi*	x		x	x	
" *palustris*	x		x	x	
" *elodes*			x		x
" *elodes jolietensis*			x		
" *reflexa*	x		x	x	x

		Recent			
	Post-Glacial[64]	Lake Michigan	Small lakes	Rivers	Sloughs; swamps
Galba reflexa walkeri			x	x	
" *exilis*			x	x	
" *kirtlandiana*			x		
" *catascopium*	x	x		x	
" *woodruffi*	x	x			

This rich and varied fauna of 115 species and 24 varieties reached its present location by way of the Chicago outlet from its place of refuge beyond the border of the Wisconsin ice sheet. Of the 139 species and races included in the table, 98 have been observed in the sediments of glacial Lake Chicago. 15 species (including 6 Pisidia) are known from the postglacial deposits, but have not yet been found living in the waters of the recent lakes and rivers. No land mollusks have been observed in the postglacial deposits, altho these animals doubtless lived on the shores of the lake as they were forest-covered. Loess deposits are known to be present near Palos Park,[66] but no mollusks have been observed.

b. Higher Invertebrates and Vertebrates of Post-Wisconsin Deposits

The other members of the fauna of the post-Wisconsin deposits, tho small in number of species, are of special interest. These are:

Crustacea
Cambarus blandingi acutus
Insecta
Donacia proxima
Vertebrata
Pisces
Amia calva
Lepomis species
Silurid or *Cyprinoid*
Aves
Mergus serrator
Mammalia
Fiber zibethicus
Mammut americanum
Elephas columbi
" *primigenius*
Odocoileus virginianus

[66] Personal communication from Dr. W. W. Atwood.

c. *Table of Species Inhabiting Wilmette Bay During Its Successive Changes*[67]

	Bowmanville Shallow water Cold temperate	Calumet-Toleston Deep water Temperate	Sag Low water Temperate	Hammond Deep water Temperate	Low water Land surface-rivers Temperate	Englewood Shallow water Temperate	Recent Land surface-rivers Temperate
Plants							
Chara			x				x
Potamogeton			x	x		x	x
Najas			x	x		x	x
Hypnum			x				x
Scirpus				x			x
Carex	x		x	x			x
Picea mariana	x		x				
Picea canadensis (=*evanstoni*)	x		x				
Larix laricina	x						x
Abies balsamea	x						
Thuja occidentalis	x						
Quercus marcyana			x				
Quercus species	x		x				x
Populus balsamifera	x						
Nymphaea advena				x			x
Typha latifolia				x			x
Mollusca							
Fusconaja undata		x					
Crenodonta undulata		x					
" *peruviana*		x	x				
Quadrula pustulosa		x	x				
" *lachrymosa*		x					
Rotundaria tuberculata		x	x				
Pleurobema coccineum magnalcustris		x					
Elliptio crassidens		x					
" *gibbosus*		x	x				
Lasmigona costata		x					
Obliquaria reflexa		x					
Amygdalonajas elegans		x					
Anodonta grandis	x		x				
" *grandis footiana*	x		x				
Proptera alata	x	x					
Eurynia ellipsiformis		x					
" *recta*		x					
Lampsilis luteola	x	x	x				
" *ventricosa*		x					

[67] This study includes only that part of the bay south of Devon Avenue. The northern part does not include all of the stages.

	Bowmanville Shallow water Cold temperate	Calumet-Toleston Deep water Temperate	Sag Low water Temperate	Hammond Deep water Temperate	Low water Land surface-rivers Temperate	Englewood Shallow water Temperate	Recent Land surface-rivers Temperate
Sphaerium flavum	x	x	x	x			
" *sulcatum*	x	x	x	x		x	x
" *solidulum*	x		x	x		x	
" *stamineum*	x		x	x		x	x
" *stamineum wisconsinensis*	x		x				
" *striatinum*	x	x	x	x			x
" *acuminatum*	x						
" *rhomboideum*		x	x	x			
" *levissimum*				x			
Musculium secure			x				
" *transversum*			x			x	x
Pisidium affine	x	x	x	x			
" *compressum*	x	x	x	x		x	
" *compressum laevigatum*			x				
" *idahoense*	x						
" *variabile*	x	x	x	x		x	
" *kirklandi*			x				
" *scutellatum*		x	x				
" *noveboracense*			x	x			
" *virginicum*		x	x	x			
" *walkeri*		x	x				
" *politum*		x	x				
" *politum decorum*			x				
" *splendidulum*		x	x	x			
" *sargenti*			x				
" *pauperculum*		x	x				
" *abditum?*			x				
Valvata tricarinata	x		x	x		x	
Somatogyrus subglobosus			x				
Amnicola emarginata	x		x				
" *limosa*	x	x	x	x		x	
" *limosa porata*			x			x	
" *lustrica*	x		x	x			
" *letsoni*		x					
Pleurocera elevatum			x				
Goniobasis livescens	x	x	x				
Campeloma integrum	x	x	x	x			
" *integrum obesum*	x						
" *subsolidum*		x	x				x
Physa warreniana	x		x	x			

	Bowmanville Shallow water Cold temperate	Calumet-Toleston Deep water Temperate	Sag Low water Temperate	Hammond Deep water Temperate	Low water Land surface-rivers Temperate	Englewood Shallow water Temperate	Recent Land surface-rivers Temperate
Physa gyrina	x		x			x	x
" *integra*			x	x		x	
Ancylus fuscus	x		x				
" *parallelus*	x		x				x
Segmentina armigera	x		x				x
Planorbis trivolvis	x		x	x		x	x
" *campanulatus*	x		x	x		x	
" *antrosus*	x		x	x		x	
" *deflectus*	x		x	x			
" *exacuous*	x		x				
" *parvus*	x		x	x		x	x
Galba reflexa	x		x	x			x
" *palustris*	x		x			x	
" *obrussa*			x				x
" *caperata*			x			x	x
Lymnaea stagnalis appressa	x		x	x			
Total species of Mollusca	36	35	58	26	0	17	13
Crustacea							
Cambarus blandingi acutus				x		x	x
Vertebrates							
Mergus serrator		x					x
Amia calva			x				x
Lepomis species			x				
Silurid or *Cyprinoid*			x				

The portion of Wilmette Bay from which the above data was obtained lies north of Foster Avenue and south of Devon Avenue. It is therefore a typical portion of the bay, the sedimentary strata of which faithfully portray the history of this body of water. The changes in the biota are marked and support the statement of Chamberlin that there should be a succession of strata after each glacial period ranging from cold to warm and from warm to cold. In this case the change is only from colder to warmer, as would be the case when but the first part of a postglacial period is included. Should the ice again form and again advance, ponding the waters of the lake, there would be a reversal of the life, ending with arctic or subarctic types, which would be covered finally by the succeeding till sheet. At Toronto the oncoming of the glacial ice is reflected in the biota and we may see the opposite of the Chicago

condition—warm–cold temperate–ice. The deposits at Chicago and Toronto, taken together form an almost continuous cycle of an interglacial interval.

The biota listed in the previous tables also present a perfect picture of the ecology of this ancient bay, the plant and animal communities reflecting the varying physical conditions as the water became shallower or deeper. As has been stated by Shimek, to interpret accurately the species entombed in these clay and sand beds, and to reconstruct the environment in which they lived, the student must have an extensive and varied acquaintance with the same animals as they are found today.

In the tables the change of types from the shallow water Bowmanville stage to the deeper water Calumet–Toleston stages, and from these to the shallower Hammond and Englewood stages is very marked, irrespective of climate. *The first stage* (36 species) had a silty, muddy bottom, supporting pond types of naiades and cyclads, and the fresh water pulmonates which usually inhabit such stations. A few gill-bearing mollusks were also present. *The second stage* (35 species) had a sandy or gravelly bottom, the water was deeper, and there was a change to the river type of naiades, the deeper water cyclads (for the most part) and a few gill-bearing species. The fresh water pulmonates were entirely absent. *The third stage* (58 species) shows a shallowing bay, the bottom becoming muddy. There was a total absence of the river type of naiades and a return of the fresh water pulmonates. The number of cyclads present is noteworthy. *The fourth stage* (26 species) shows a return to deeper water with a sandy or silty bottom, inhabited by a few cyclads and gill-bearing species, with fresh water pulmonates. There was a total absence of naiades. *The fifth stage* was probably a land surface with a few creeks. No life has been observed from this stage. In *the sixth stage* (17 species) the bay had become still shallower, the life consisting of a few cyclads, a very few gill-bearers, and a number of fresh water pulmonates. The bottom was covered with mud and fine silt. *The seventh* and last stage is of the present time (13 species) the water has receded and the surface has become dry land with a few small ponds and swampy streamlets. Here the molluscan fauna consists of pulmonates, with a very few cyclads. The ecological succession shown by these seven stages is approached in completeness only at Toronto, Canada, where a somewhat similar alternation of strata occurs.

The vertebrates of the Chicago deposits, while not numerous in species, are of great interest, and include fish (3 species), birds (1 species), and mammals (5 species). We can imagine the waters teeming with fish life, the presence of ducks on the surface of the lake and bays, and the deer, mastodon and mammoth roaming the shores, while squirrels chased one another among the tree tops. It is also probable that the caribou, musk ox, snow goose, and other tundra animals inhabited the region, and during warmer times the peccary may have lived here, as its remains have been found in Ohio, Michigan, and

at Rochester, N. Y. Early in the lake history a vigorous forest of spruce also gave a boreal aspect to the country.

J. CORRELATION OF LOCAL AND GREAT LAKES STAGES[68]

Lake Chicago Basin[69]

Glenwood stage, 640-635 feet.
  Outlet at Chicago.
  Fluctuation of ice front.
Bowmanville stage, 590 feet.
  Outlet possibly north of Green Bay.
  (Possible relation to Lake Wayne.)
  Readvance of ice.
  (Possible second Glenwood stage.)
Calumet stage, 620-615 feet.
  Outlet at Chicago.
  Ice front reaches Straits of Mackinac and Lake Chicago unites with Lake Huron. A portion of the Toleston stage probably belongs to this episode.

Huron–Erie Basin

Highest Maumee, 790 feet.
  Outlet at Fort Wayne, Ind.
Lowest Maumee, 760 feet.
  Outlet near Imlay, Mich., to Chicago.
  Readvance of ice
Middle Maumee, 780 feet (L. Saginaw).
  Outlet thru Imlay channel.

Huron-Erie-Ontario Basin

Lake Arkona, 710-694 feet.
  Outlet, Grand River to Chicago.
  Readvance of ice.
Lake Whittlesey, 735 feet.
  Outlet, Grand River to Chicago.
Lake Wayne, 660 feet.
  Outlet past Syracuse to Hudson River.
  Readvance of ice.
Lake Warren, 680 feet.
  Outlet, Grand River to Chicago.
Lake Lundy (Grassmere 640, Elkton 620 feet).
  Outlet past Syracuse to Hudson River.

LAKE ALGONQUIN

Chicago Basin

Toleston stage, 600-605 feet.
  Union of lakes.
Sag low water stage, 590 feet.
  Possibly dry land (Taylor).
Hammond stage, 600 feet.
  Outlet at Chicago.
Low water stage, 580 feet (or less)
  Probably dry land.

Englewood stage, 592 feet.
  Closing of Chicago outlet.

Present stage, 580 feet.
  Dry land and rivers.

Huron–Ontario Basin

First stage.
  Outlet to Lake Erie.
Kirkfield stage.
  Outlet thru Trent Valley.
Port-Huron-Chicago stage.
  Outlets at Chicago and St. Clair.
Closing stage.
  Outlet into Champlain Sea, via Ottawa Valley (North Bay).
Nipissing Great Lakes.
  Two outlet stage, North Bay and Port Huron.
Great Lakes.
  Outlet at Niagara Falls.

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[68] After Leverett and Taylor.

[69] The relation of the moraine near Milwaukee (Whitehall) and that near Two Rivers (Manistee) to the rising of the water level succeeding the Bowmanville stage is not definitely known The latter does not carry the high water beaches (60 and 40 feet) while the former is said by Goldthwait to show traces of these beaches in Sheboygan County. The lake possibly fell from the Glenwood to the Calumet level before the low water stage and the lake sub-

K. ALTITUDE OF OLD LAKE BEACHES

Dr. Goldthwait has measured the altitude above sea level of the three highest beaches at several widely separated localities,[70] and his data are of interest in connection with the previous discussion.

	Glenwood	Calumet	Toleston
Evanston and Niles Center, Ill.	636	619	605
Zion City, Illinois	643	621	....
State Line, Illinois and Wisconsin	634	616	....
Line between Racine and Kenosha counties	637	621	....
Holland, Michigan	638	621	605
Spring Lake and Eastmanville, Mich.	633	613[71]	602
South end of Lake Michigan basin	636	619	604

L. INTERGLACIAL LIFE OF THE CHICAGO AREA

Well records from different parts of the region indicate that more than one ice sheet passed over the Chicago Area. Other preglacial conditions are also indicated in several places. A buried valley enters the lake near Lincoln Park, and can be followed for several miles back from the lake, in a northwesterly direction. The wells drilled along this valley penetrate rock at 115 to 125 feet below lake level.[72] Rock is found at varying depths showing that the region had suffered marked erosion previous to the glacial period. Some of the depths at which rock has been found, and the location of the wells, is of interest and illustrates this variation.

Wilmette	140	Turner Park	80
Bowmanville	80	Washington Heights	71
Jefferson Park	68	Morgan Park	90, 163
Irving Park	79	Riverdale	45
Norwood Park	90	Dalton	35–40
Near County Infirmary	71 to 101	Harvey	20–25
Oak Park	45, 65, 85.	Glenwood	30–35
Near Cragin	20	2½ miles north of Arlington Heights	195

sequently rose to the Calumet level after the low water stage. It is also possible that the low water stage was inter-Glenwood, as is suggested by some of the results of Alden's studies near Milwaukee.

[70] Journ. of Geol., XVI, p. 464, 1908.

[71] Very obscure, probable error of few feet (Goldthwait).

[72] Leverett, Illinois Glacial Lobe, pp. 583-590.

In the northwestern part of Cook County, wells penetrate a black soil below till at a depth exceeding 100 feet.[72] This is probably post-Illinoian or Sangamon in age. Near Elgin a lower till is encountered at 67 to 70 feet. In other places near Elgin the lower till occurs at 165 feet. Near Arlington Heights a black soil was observed beneath blue till at a depth of 70-75 feet, under which there was another till sheet.

In Township 41, Range 10 east, a well section shows the following strata:[73]

Yellow till	10-15 feet
Blue till	125 "
Black soil	4 "
Sandy till	50 "
Gravel with water	2 "

A section of the Joliet Mound, near the city of Joliet, presents interesting data.

Surface coating of silty clay	1–4 feet
Coarse gravel and cobble	10–12 "
Sandy gravel of medium coarseness cemented in places	25–30 "
Fine sand or loam	4 "
Blue pebbleless clay, laminated, calcareous	8–10 "
Boulder bed, containing clay balls and a sandy clay matrix, extending to level of river on east side of mound, but underlaid at slight depth by limestone at west side	5–20 "

The boulder bed is believed to be the result of interglacial erosion of a till sheet.[74]

Illinoian drift is known to underlie Wisconsin till at a depth of 160 feet at Barrington, Lake County.[75] Two miles east of Beecher, Will County, an old soil lies beneath 50 feet of glacial gravel.[76] East of Summit, Cook County, an older till underlies the Wisconsin till.[77] No specific evidences of life have yet been recorded from these old deposits.

M. SUMMARY

The detailed studies discussed in the previous pages may be summarized as follows:

1. During the late Wisconsin ice invasion all life which occupied the Great Lakes region and the northern part of the United States, as well as nearly all of British America, was destroyed or driven southward. As the ice sheet retreated, the biota followed as closely as climatic conditions would permit.

[73] *Op. cit.*, p. 586.
[74] Leverett, *op. cit.*, p. 377.
[75] *Op. cit.*, p. 581.
[76] *Op. cit.*, p. 651.
[77] *Op. cit.*, p. 407.

The sequence of these postglacial episodes is known to be very complicated, the biota varying with the changes of conditions.

2. During the Glenwood Stage there was no life excepting, perhaps, wandering mammoths, mastodons or other mammals which may have strayed northward.

3. Following the Glenwood Stage there was a period of low water during which the level of the lake dropped to about ten feet above the present level, or 590 feet above sea level. At this time an abundant and varied fauna, consisting principally of mollusks, took possession of the shallow bays. This fauna consisted of shallow water types, such as are now found in small bays connected with the Great Lakes. A rich forest of spruce and tamarack, fir, arbor vitae, poplar and oak took possession of the dry land, and shallow water vegetation, such as *Chara* and *Potamogeton*, must have filled the water; *Typha* and probably other aquatic plants, lined the shores of the embayments. This biota extended as far north as Manitowoc County, Wisconsin. The reasons which may be assigned for the fall of the water are the rapid melting of the ice in the Michigan basin, the possible opening of a temporary outlet north of the Green Bay Valley or the shifting of the outlet in the Huron-Erie-Ontario basin to the Mohawk Valley past Syracuse. All of these factors may have contributed.

4. Following the low water stage the lake again raised its level, due to a readvance of the ice, or to the return of the use of the Grand River outlet, and formed the Calumet Stage, the water standing from 35 to 40 feet above the present lake level, or 615 to 620 feet above sea level. It is possible that the lake may have returned to the lower Glenwood level and then suddenly dropped to the Calumet level. At this time an off-shore barrier was formed, extending from Wilmette south to Bowmanville. West of this bar Wilmette Bay developed. No life has been found in the beaches referable to this period of the lake's history, but it is quite probable that between the Calumet and Toleston stages the forerunners of the rich Toleston biota took possession of the waters. The naiad fauna observed in the Sag-Calumet channel may belong to this transition period.

5. The water gradually fell (due to cutting down of the outlet) to about 20-25 feet above the present lake level (600-605 feet above sea level) forming the Toleston Stage. The Rose Hill bar became wide and peninsular-like and an off-shore barrier developed (the Graceland bar) and extended from Bowmanville south to Lincoln Park. Wilmette Bay was now ten miles long, two to three miles wide, and five to twenty feet deep. A rich fauna of river mussels (Naiades, Unionidæ) took possession of Wilmette Bay and Lake Chicago, forming huge beds comparable to those now exsiting in the larger rivers of the Mississippi Valley. Two species of naiads and one gastropod do not now live in the Chicago area; one, *Elliptio crassidens*, extended its range as far north as

Green Bay, Wisconsin, but is not now found within a distance of 80 miles from the latter locality or Chicago. It is likewise not now living in the Great Lakes drainage. The other naiad, *Pleurobema coccineum magnalacustris*, is not now found in the Mississippi Valley drainage. The same may be said of the gastropod, *Amnicola letsoni*. One species of bird (*Mergus serrator*) lived at this time, as did also the mastodon, mammoth, and a species of deer. Shallow water types of mollusks lived in the shallow water near the shore.

6. The lake suffered a second low water period forming the Sag Stage, when the lake fell to about 10 feet above the present level. The life of this stage is the richest of all the episodes, including 75 species and varieties of mollusks, 3 species of fishes and two or more species of mammals. The increase in the Pisidia as well as in the fresh water pulmonates is noteworthy, as is also the absence of the heavy naiades. During this stage the outlet was by way of the Trent Valley and the Chicago outlet was used only in a slight degree.

7. The lake rose again (due to differential uplift) to the 600 foot level, forming the Hammond Stage (Lake Algonquin outlet shifted to Chicago). The life of this stage consisted of species of mollusks (39) typical of quiet waters of large size and moderate depth, such as bays and ponds. In place of the ponderous naiads there were a number of species of the smaller bivalves (Sphaeriidae) and a large percentage of shallow water gastropods, principally fresh water pulmonates, which became widely distributed. A few species of the naiades remained in the more open parts of the lake. Crayfish were abundant in the shallower parts of the bays.

8. A third period of low water (or possibly a land surface) followed the Hammond Stage, after which the water rose to a higher level forming the

9. Englewood Stage, the level being about 12 feet above the present lake. The Wilmette embayment became reduced to a bay about seven miles long, from one-half to one and a half miles wide, and from one foot to twelve feet in depth. The molluscan fauna consisted of a few shallow water bivalves and gastropods. The naiades probably retreated to the beds of the rivers Chicago, Desplaines, and Calumet, as well as to the lakes left in the southeastern portion of the lake basin. Bars were formed which finally shut in the Chicago basin north of the Sag outlet, causing a huge marsh to develop.

10. When the water fell to the present level of Lake Michigan the aquatic life retreated to the rivers, ponds, lakes, and small streams. Wilmette Bay became a marsh, wet during the spring and dry during the fall. The region of the Sag outlet was shut off by bars and also became a great marsh.

11. The Illinoian ice sheet passed over the Chicago region and upon this till an old soil was formed. Rock valleys also occur indicating preglacial erosion.

CHAPTER IV

THE POSTGLACIAL BIOTA OF THE GREAT LAKES REGION

I. General Statement

A study of the life of any given region naturally and logically leads to a consideration of the life of other regions more or less related to the particular area under discussion. In the present instance this study and comparison is quite essential, since the aquatic repopulation of the glaciated area was probably largely by way of the Chicago outlet.

Records, more or less complete, are available from various places adjacent to the basin of the Great Lakes, clearly indicating that the biota followed the retreat of the ice and occupied the territory as fast as it became available for the different types of life. The lake sediments and beaches in Wisconsin, Illinois, Michigan, New York, and various parts of Canada contain, in a few localities, an abundance of biotic remains. No studies, comparable with those carried on in the Chicago basin, the details of which have been indicated in the preceding pages, have been made in any of these deposits.

II. Outline of the History of the Extinct Lakes

Before proceeding to discuss the various deposits in which evidences of life have been found, it will be necessary to consider briefly the succession of lakes formed at the margin of the retreating ice sheet.[1]

A. THE WISCONSIN ICE SHEET (Plate XLVI)

The last glacial invasion extended well into the United States, completely covering the Great Lakes with ice, and sending two large lobes into the territory west of the Mississippi River, one into Iowa and one into South Dakota. The life of the englaciated region was driven south and occupied the territory as near the ice margin as the rigor of the climate would permit. The aquatic life found refuge in the Mississippi, Rock, Illinois, Wabash, Ohio, and Missouri rivers and their tributaries, from which territory it was ready to advance as soon as the ice sheet began to retreat.

B. FORMATION OF GLACIAL LAKES

"As the ice border withdrew to the north of the divide separating the St. Lawrence basin from the Mississippi basin, the glacial waters were ponded be-

[1] This discussion is compiled from the papers of Leverett, Taylor, Goldthwait, and Chamberlin. The early and late Wisconsin ice sheets are considered together.

tween the ice on the north and the divide on the south. To find escape across the divide, the waters were compelled to rise to the heights of the lowest available colls. At first, nearly every considerable depression in the divide to the south was occupied by a discharging stream, and the ponded water to the north formed innumerable small lakes. But as the ice retreated farther into the basin, the sizes of the lakes tended to increase as their basins were enlarged; but at the same time the ponded waters tended to unite along the edge of the withdrawing ice, and to utilize only the lower passes across the divide to the south. This tended to lower the lakes, and hence to reduce them. There thus formed a complex series of antithetical changes resulting in the making and unmaking of lakes. This continued until the obstructing ice withdrew from the axis of the St. Lawrence basin. The last of the shifting series of ice-ponded lakes of this basin then disappeared, leaving the present rock-bound lakes as their successors."[2]

C. LAKE MICHIGAN BASIN; LAKE CHICAGO

One of the first lakes to take definite form is known as Lake Dowagiac, which extended northeasterly and southwesterly across southwestern Michigan, and drained into the Illinois River via the Kankakee River (Plate XLVII, figure 1). It is not definitely known whether any life migrated into this region from the Illinois River via the Kankakee River. Many of the small lakes which now occupy the territory once covered by glacial Lake Dowagiac contain marl deposits beneath two or three feet of peat and swamp deposits. These deposits contain life which could have inhabited a cold temperate region (see below under Michigan-Magician Lake).

As the Michigan lobe retreated into the Michigan basin, a small lake formed behind the Valparaiso moraine, extending an arm northeasterly into Michigan, into which the Paw Paw and St. Joseph rivers emptied. This lake, known as Lake Chicago, drained southward into the Illinois River via the Desplaines River (Plate XLVII, figure 2). As the Michigan lobe melted back, Lake Chicago extended in area toward the north until it filled the entire lake basin (see Plate LI). These different lake stages are discussed in the previous chapter.

D. LAKE SUPERIOR BASIN; LAKE DULUTH

As the Superior lobe melted and withdrew into the Superior basin a small lake, known as Lake Upham, formed on the north side. This soon enlarged and formed Lake Duluth, which drained into the Mississippi River via the St. Croix River (Plate LI). Several small lakes, more or less transitory, developed before the formation of Lake Duluth. The ice finally retreated from the Superior basin and Lake Duluth coalesced with Lake Algonquin.

[2] Chamberlin and Salisbury, Geology, III, p. 395.

E. GREEN BAY BASIN

The history of this region is not yet fully worked out but is believed to be as follows: "there was first a lake that discharged from the district south of Lake Winnebago southward past Horicon into Rock River. This lake persisted until the ice which formed the moraine at the head of Lake Winnebago had receded far enough northward to open a passage westward from Oshkosh to the head water part of Fox River. Then the discharge was shifted past Portage to the Wisconsin Valley. Later, when the melting of the ice cleared the Green Bay peninsula the waters lowered to the Lake Winnebago level and to a lake in the Green Bay basin by discharging eastward into Lake Chicago."[3] (Plates XLVIII, XLIX.)

F. HURON-ERIE BASIN

This basin lies south of Saginaw Bay and is continuous with the Erie basin across the Canadian peninsula. Converging ice currents became confluent in this basin and formed the Huron-Erie ice lobe. This basin has had a very complicated history, changing in outline as different outlets were uncovered, one after another, as the ice receded.[4]

Lake Maumee

The Erie lobe formed several small lakes on its margin which finally united to form Lake Maumee, at the southwest end of the basin, which found an outlet past Fort Wayne, Indiana, to the Wabash River; this is known as the Fort Wayne outlet (Plate XLVIII). Lake Maumee continued during three stages, during which the level of the water fell 30 feet and the outlet changed several times. The Fort Wayne outlet formed the first stage (altitude 790 feet above tide). As the ice melted back, the lake expanded over the low country, east and north, finding an outlet at Imlay, Michigan, into the Grand River, and thence into Lake Chicago. This is known as the second stage and is 10 feet lower than the first stage (780 feet). Further recession of the ice border uncovered lower outlets, one near Ubly and one farther north, and the Imlay outlet was abandoned, as was also the outlet by way of Fort Wayne into the Wabash River. This formed the third stage, the level of the lake being 760 feet.

G. HURON-ERIE-ONTARIO BASIN

1. *Lake Arkona*

For some reason, not yet well understood, the lake waters were drawn down to a much lower level (altitude 710-694 feet). This lake filled much of the Saginaw basin, and is also believed to have extended as far east as Alden, New

[3] Taylor, An. Rep. Smith. Inst., 1912, p. 314.

[4] Leverett, 12th An. Rep. Mich. Acad. Sci., page 30; Taylor, *op. cit.*

York. A similar lowering of the lake level is believed to have occurred in the Michigan basin.

2. *Lakes Whittlesey and Saginaw*

A readvance of the ice raised the water to the Ubly outlet forming Lake Whittlesey (altitude 735 feet). A small lake at the margin of the Saginaw lobe has been called Lake Saginaw (Plate XLIX). The discharge was by way of the Grand River into Lake Chicago and thence to the Mississippi River by way of the Chicago outlet.

3. *Lake Wayne*

From the Whittlesey beach the lake dropped 80 or 85 feet to a lower beach known as the Wayne beach (altitude 660 feet). "The drop in the lake level was, of course, due to a movement of retreat on the part of the ice front. The Wayne beach lies at a level in the Saginaw Valley barely below the head of the channel, which had served as the outlet of Lake Saginaw. At the same time it is quite certain that no outlet was open toward the northwest through the straits of Mackinac. The outlet at the time of this beach seems to have been in the east along the ice margin, where it rested against the hills south of Syracuse."[5]

4. *Lake Warren*

Continued shifting of the ice border caused the waters of Lake Saginaw and Lake Wayne to become confluent and a large lake developed known as Lake Warren (Forest beach, altitude 680 feet), which discharged into Lake Chicago via the Grand River. To the eastward, it extended as far as the Finger Lake region of northern New York (Plate L). As the ice melted back into the Ontario basin passages were opened for the eastward discharge of the waters of Lake Warren past Syracuse, New York, to the Mohawk Valley and thence into the Atlantic Ocean by way of the Hudson River.

5. *Lake Lundy* (*Lakes Dana and Elkton*)

A later stage of the Warren water is called Lake Lundy, during which time two lake beaches (Grassmere, 640 feet; Elkton, 620 feet) were formed; the discharge was eastward past Syracuse. Taylor remarks that "these beaches mark a transition stage of the lake waters—the transition to Lake Algonquin, the largest of the glacial lakes in the Great Lakes region" (Plate LI).

It will be noted that there are recorded six distinct stages of the waters of the Huron–Erie–Ontario basins; four stages with outlets via Chicago, and two stages with probable outlets eastward via the Mohawk Valley. This, of course,

[5] Taylor, An. Rep. Smith. Inst., 1912, p. 306.

represents the advances and retreats of the ice sheet. This condition may be expressed as follows:

Lakes of Huron-Erie-Ontario Basin

1. Lake Maumee. First stage, Fort Wayne-Wabash outlet.
   Second stage, Imlay-Chicago-Grand outlet.
   Third stage, Ubly-Chicago-Grand outlet.
2. Lake Arkona. Chicago-Grand outlet.
3. Lake Whittlesey. Chicago-Grand outlet.
4. Lake Wayne. Syracuse-Mohawk outlet.
5. Lake Warren. Chicago-Grand outlet.
6. Lake Lundy. Syracuse-Mohawk outlet.

6. *Lake Erie*

The ice eventually shrank within the Ontario basin and the discharge was shifted to a low coll at Rome, New York. This lowered the waters about 150 feet below the crest of Niagara Falls and the cataract came into action. The waters of the Erie basin were drawn down to the level of the Niagara River outlet. The first Lake Erie beach lies within the present Lake Erie and it is believed that this lake began as a small body of water in the eastern end and gradually filled the basin to the west. Submerged lower courses of streams in the west end of the basin present conclusive evidence of this ancient condition. During its postglacial existence, Lake Erie has had two periods of low water, one at the time of the Kirkfield (Trent River) outlet, and the second at the time of the North Bay (Ottawa River) outlet. Both lower beaches are now submerged.

H. ONTARIO BASIN (LAKE IROQUOIS)

"When the Lake Ontario ice lobe had retreated far enough to uncover the southern parts of the valleys of the Finger Lakes in central New York, small lakes gathered in them, at first as separate bodies. With continued recession these lakes were lowered and combined in a complex series of changes leading finally to the later, large lakes that filled the whole basin of Lake Ontario. The first local glacial lakes had independent outlets toward the south" (Taylor).

The dozen or more small lakes in the Finger Lake valleys finally merged into one lake, Lake Newberry, with an outlet southward from Seneca Lake to the Susquehanna River.[6] Later, Lake Hall followed with an outlet westward to the Lake Erie basin. Lake Van Uxum followed, with an outlet eastward to the Mohawk Valley. Next came Lake Dawson, when the waters fell below the level of Lake Erie, and the outlet was eastward past Syracuse. Finally, Lake Iroquois was formed, when the waters of the Ontario basin fell to the level of the pass at Rome, N. Y., and discharged eastward thru the Mohawk Valley into the Hudson River and thence to the Atlantic Ocean (Plate LII).

[6] See Fairchild, Bull. N. Y. State Museum, No. 127.

When the ice withdrew from the Adirondacks the lake waters were lowered and an outlet was found lower than the Mohawk Valley. The first lower outlet was into glacial Lake Champlain and thru the Hudson River. Further retreat of the ice uncovered the Atlantic coast and the basin became filled, more or less completely, with sea water (Plate LII) during a period when the ice had opened a passage to the eastward. Subsequent differential uplift brot Lake Ontario to its present level and gave it an outlet thru the St. Lawrence River.

I. LAKE ALGONQUIN

The early history of the post glacial lakes has up to this time required a separate discussion for each lake basin. At this time, however, the waters of the basins of Lakes Superior, Michigan, and Huron united, forming a lake considerably larger than the present Great Lakes, and known as Lake Algonquin (Plate LII). Lake Algonquin may be divided into four stages which are summarized as follows:

1. *Early Lake Algonquin.*[7] At the beginning the lake probably had a brief stage when it was confined entirely to the southern half of the Huron basin (Plate LII). This was of short duration, a slight additional retreat of the ice uncovering outlets to the northwest to Lake Chicago and to the east to Georgian Bay and the Trent Valley. The St. Clair and Detroit rivers were also used by the waters to find an outlet thru the Niagara River to Lake Iroquois.

2. *Kirkfield Stage.* As soon as the ice melted back far enough to uncover the Trent Valley, the level of the waters fell, the outlets at Port Huron and Chicago were abandoned, and the full discharge of the waters was thru the Trent Valley at Kirkfield. It is believed that Lake Iroquois had already been established when the Kirkfield outlet was opened.

3. *Port Huron-Chicago Stage.* When the ice sheet had almost entirely disappeared from the lake basins, a movement of differential elevation began which raised the land at Kirkfield and the outlet was again shifted to Port Huron and Chicago. At first the Chicago outlet carried the greater part of the water, but as this outlet rested on a sill of rock while the Port Huron sill was of till, the latter was soon cut down and carried almost all of the overflow.

During this third stage the remarkable uplift of the Great Lakes region occurred. This uplift caused a northward splitting and divergence of the beaches below the highest Algonquin beach, the difference in elevation between the beach at Port Huron and the high beach at Lake Gondreau, Canada being 900 feet. The beaches fall into three groups, (1), the upper main Algonquin group, (2) the Battlefield group, and, (3) the Fort Brady group. It is believed that these deformations were not slow and evenly distributed but were spasmodic, and relatively sudden and rapid (Taylor).

[7] Taylor, *op. cit.*, pp. 316-320.

4. *Closing Transition Stage.* At its end Lake Algonquin appears to have been held up by a small glacial barrier, at some point in the Ottawa Valley east of Mattawa. When this last dam was removed the waters rushed eastward thru the Ottawa, Petawawa, and Madawaska valleys to the Champlain Sea and came to a settled level in the upper lake basin only when the eastward flowing outlet had been established on the coll at North Bay (Taylor). The discharge from Port Huron was abandoned at this time (Plate LIII).

J. NIPISSING GREAT LAKES (Plate LIII)

At this time the ice sheet had disappeared from the Great Lakes region and did not act as a barrier. The entire discharge was into the Champlain Sea via the North Bay outlet. These lakes differed but little in outline from those of today. Differential uplift in the North Bay region soon caused the abandonment of the North Bay outlet which was shifted to Port Huron and Chicago, the waters backing up at these localities. For a time both the North Bay outlet and the Port Huron outlet were active and a transition or two outlet stage ensued. Later, the Chicago outlet took the place of the North Bay outlet but this was abandoned when the Port Huron waters had cut down the outlet, and the present Great Lakes resulted, the Chicago outlet being left as a marsh. The Nipissing beach is one of the strongest of the old lake beaches and has been traced entirely around the Great Lakes. Before reaching its present level, the Great Lakes constructed other beaches, one, known as the Algoma (seen at Algoma Mills, Ontario) is 35 feet below the Nipissing beach and 50 feet above Lake Huron. Other minor transition beaches are known.

K. THE CHAMPLAIN SUBSTAGE (Plates LII, LIII)

During the latter part of the Port Huron stage of Lake Algonquin, the land was notably depressed in the eastern part of the territory and became partly submerged by an arm of the sea which filled part of the Lake Ontario basin, extending up the Ottawa Valley past the city of Ottawa and also occupying the Lake Champlain basin, and extending down the Hudson River Valley to the sea at New York. The old shore lines now stand at elevations of from 400 to 625 feet above the present sea level. The New England states and a portion of Canada formed an island surrounded by salt water. At this time the eastern outlet was lower than either the Chicago or St. Clair outlets and the lake was somewhat smaller than at present in both the Michigan and Huron basins. This condition did not last for a great length of time and subsequent uplift caused the sea to recede and the outlet to be transferred again to the St. Clair River and the five Great Lakes assumed their present form, with the outlet thru the St. Clair and St. Lawrence rivers.

L. GLACIAL LAKE AGASSIZ (Plate XXXI)

"A very important lake was also formed in the Red River Valley of the North, discharging in its early history into the Minnesota River at Lake Traverse. As Lake Agassiz was not connected with the complex system of basins of the St. Lawrence Valley, it had a comparatively simple history. It grew to the northward with the retreat of the ice which held it in at that end, and continued to discharge into the Minnesota River at Lake Traverse, cutting down its outlet and forming a series of breaches about its borders, until the retreat of the ice enabled it to find a northerly outlet in some position yet unknown. While discharging by this northerly outlet, it made another set of beaches. On the further withdrawal of the ice, its waters were discharged, and the lake became extinct. Lakes Winnipeg and Winnipegosis may be regarded as its diminutive successors in a sense, but they are rockbound lakes, while Lake Agassiz was ice-bound on its northerly border."[8] Lake Agassiz is believed to be contemporaneous with Lake Algonquin (vide Leverett).

Many lakes of greater or less size were formed at the borders of the Minnesota and Dakota lobes of the ice sheet. Lake Dakota, formed as the Dakota lobe receded in South Dakota, is of interest in this connection, but no detailed studies have been made of its old shore lines or life, if, indeed, there was any life in its icy waters.

III. Postglacial Sedimentary Deposits Containing Remains of Life

Sedimentary deposits containing the remains of life have been observed in many places. Some of these are referable to precise lake stages, but many are in equivocable deposits and cannot be so classified. The data at hand, old as well as new, are discussed by states, first considering those adjacent to the Great Lakes and finally those from more remote regions; all are, however, in territory once covered by the Wisconsin ice sheet. The modern nomenclature is used for the lists of species.

A. GREAT LAKES REGION

I. WISCONSIN

References to postglacial lacustrine deposits from this state are apparently rare, none being observed that record remains of life except those of Baker[9], Wagner,[10] and Goldthwait.[11]

[8] Chamberlin and Salisbury, Geology, III, p. 402. See also Upham, The Glacial Lake Agassiz.

[9] Journ. Cin. Soc. Nat., Hist., XIX, p. 175; Nautilus, XXVII, p. 68.

[10] Nautilus, XVIII, pp. 97-100.

[11] Abandoned Shore Lines, p. 61; Alden, Science, XXIX, p. 557.

1. *Bowmanville Low Water Satge*

The buried forest at Two Creeks, described by Goldthwait[11] is possibly referable to this stage, the overlying red till being laid down by a moraine of the Lake Michigan lobe during one of its advances. It has been suggested by Alden[11] that it might be interglacial and referable to the Peorian interval, but it seems to be related rather to the last Wisconsin episode and to be coeval with the deposits which overlie the boulder clay at Chicago. Goldthwait thus describes this ancient forest bed:

"Laminated red clays formed the base of the section, up to two or three feet above the water. Above this, and separating it from a twelve-foot sheet of stony red till was a conspicuous bed of peat, sticks, logs, and large tree-trunks, which unmistakably represent a glaciated forest. The till immediately above the forest bed, besides containing characteristic subangular striated stones and red clay ismilar to the clay in the stratified beds below, all absolutely unassorted, was plentifully mixed with broken branches and twigs. In the underlying forest bed the stumps were well preserved, the wood being soft and spongy like rotten rubber, but retaining all the appearance of its original structure. Several logs and stumps lay pointing significantly towards the southwest, the direction in which the ice sheet probably moved at this place. One little stump, however, with its ramifying roots firmly fixed in the laminated red clays, stood erect as when it grew there, but it had been broken short off at the top, where the ice sheet, dragging its ground moraine along had snapped off the top without uprooting the tree."

The age of the deposit is thus commented upon by Goldthwait: "The Two Creeks forest may then record an interval between early and late Wisconsin time; or it may mark an interval between the Calumet stage and the readvance of the ice sheet to the Manistee moraine." The writer believes the deposit to be referable to the low water interval following the Glenwood stage of Lake Chicago, and that the deposit underlies both the Whiteall and Manistee advances of the Lake Michigan glacier. Lawson[12] records many instances of the presence of old forest beds at various depths beneath the surface. Some of these are doubtless to be classed with the deposits at Two Creeks, but the majority appear to be referable to the Sangamon or Peorian interglacial intervals. These are referred to in a subsequent chapter.

Several years ago Wagner[10] recorded the finding of a specimen, of *Unio (Elliptio) crassidens* at Green Bay. The specimen, a left valve with the posterior portion somewhat broken, was found in the city of Green Bay during excavation for the city reservoir. The deposit was about 15 feet below the surface, and was thot by Wagner to be till, but was more likely silt. The deposit may be the same as the one containing the forest remains and referable

[12] Bull. Wis. Nat. Hist. Soc., II, p. 170, et seq.

to the Bowmanville stage or it may be later date, possibly early Toleston. The presence of this mollusk so far north of its present range is of great interest, especially in collection with the Chicago record, showing a decided northward dispersal during postglacial times. It is probable that this species will eventually be found in other deposits north of its present range. A survey of the Green Bay deposits to ascertain the area in which this species is preserved and also to discover what species were associated with it would be of great interest and value. This fauna probably migrated up the Wisconsin or Fox rivers.

2. *Toleston or Hammond Stage*

Some years ago Mr. A. W. Slocum, of the University of Chicago, collected a number of mollusks from postglacial deposits in the city of Milwaukee and its environs. These deposits are thus described by Mr. Slocum: "The Bay View locality is on the bank of Lake Michigan about a mile south of the steel works. It consists of a marl bed about seven feet in thickness which has been uncovered by the action of the waves. The 30th Street locality is in the city of Milwaukee near the intersection of 30th Street and Garfield Blvd. This is a small, saucer shaped depression occupying not more than one or two acres. The greatest thickness is about 13 to 15 feet and pinches out in all directions, roughly circular. Underneath the filling is a layer of peat about 2 feet in thickness and below this is a blue clay extending down to the till beneath. At the bottom of this blue clay the bones of an elephant were found. This section was opened up by a sewer being run through 30th Street.

"The shells were found at about the junction of the peat and clay. The fauna at the two localities was very similar, tho the relative abundance of the species varied materially. *Galba palustris* and *Valvata sincera* were much more abundant at the 30th Street locality than at Bay View. *Planorbis campanulatus* and *Physa ancillaria* were among the most abundant shells at the Bay View locality and were rare at 30th Street. The bivalves were much more abundant at 30th Street than at Bay View. About three miles west of the 30th Street locality, in the town of Wauwatosa, the marl is reported to occur, although I have not seen it there." The species collected are listed below:

Anodonta species	*Physa ancillaria*
Sphaerium simile	*Planorbis campanulatus*
" *rhomboideum*	" *antrosus*
Valvata sincera	" *antrosus striatus*
" *tricarinata*[13]	" *deflectus*

[13] In the list of species first recorded ecarinate and bicarinate forms of *Valvata tricarinata* as well as *Physa heterostropha* were recorded. The Valvatas prove to be degrees of carination and not true bicarinate and ecarinate varieties. The *sincera* is Say's species (*vide* Walker) The *Physa* proves to be a form of *ancillaria*.

Amnicola limosa	*Galba reflexa*
" *lustrica*	" *palustris*
" *cincinnatiensis*	" *obrussa decampi*

The absence of detailed information relative to the stratigraphy of the Milwaukee strata renders the correct placing of the deposits observed by Slocum very difficult. The peat stratum may record a low water stage or land surface, probably of early date, perhaps between the Toleston and Hammond stages. There may have been a small bay in the region now occupied by the Milwaukee and Menominee rivers during one of these stages. Alden[14] describes marsh deposits at the confluence of these two rivers at depths of 20 to 53 feet below the level of Lake Michigan, indicating that at some time the waters of the lake fell very much lower than during the stages which built up the beaches. Alden believes this period of erosion to have followed the Calumet stage. The writer believes that the low water period following the Toleston (as outlined in the previous chapter) was the time of this very low water stage and that there was a period of dry land. The Marsh deposits beneath beach gravel at Kenosha evidently underlie the Englewood beach (Nipissing stage).

The shells mentioned by Whittlesey[15] as occurring in yellowish compact clay and hardpan 12 to 24 feet above the level of the lake at Milwaukee probably came from the same horizon as the shells collected by Mr. Slocum. Five species are identified.

Planorbis campanulatus
Paludina decisa (=*Campeloma decisa*)
Melania depygis (=*Goniobasis depygis*). This was probably *livesoens* rather than *depygis*.
Limnaea desidiosa (=*Galba obrussa*)
Cyclas similis (=*Sphaerium sulcatum*)

Recently, Mr. J. R. Ball, of Northwestern University, has brought to my attention a deposit containing molluscan shells in the ravine of a small creek entering Lake Michigan at Kenosha, Wis. which possibly belongs to the same stage as the marsh deposits recorded above by Alden. Mr. Ball describes the locality as follows: "The small creek (Pike Creek) has a rather wide valley, showing numerous cut-offs and abandoned meanders, and, at several turns in the present stream, where banks ranging from three to five feet in height have been cut out, the enclosed specimens were found. They were not very abundant and are not to be seen elsewhere than where found, viz., about one foot or ten inches from the present valley floor. They are found in a rather sandy formation, darkly stained with organic matter, which overlies a clay formation which weathers in rectangular fashion, and which is also stained

[14] Milwaukee Folio, p. 9.
[15] Bull. Geol. Soc. Amer., XXII, p. 215.

a dark color. In some instances, a faint approach to stratification may be seen, showing more prominently at the junction of the sand and clay. The floor of the valley in which I find these forms is not more than eight or ten feet above the present level of Lake Michigan. In no case have I found any formation overlying the one containing the shells, such as till, clay, etc., but always as previously described" [in letter].

The shells found by Mr. Ball are as follows:

Sphaerium sulcatum	*Planorbis parvus*
Physa species, fragments	*Planorbis hirsutus?*
Pyramidula alternata, young	

3. *Strata of Uncertain Age*

There are several records which cannot be definitely correlated with any of the lake stages. Slocum's record of elephant remains at the base of the blue clay in the Milwaukee section may be referable to the Bowmanville low water stage. Calvin[15a] states that in 1876 a complete skeleton of an elephant was found near Adel, Dallas Co., in peat which partly filled a 'kettle' in the Wisconsin drift.

A few years ago Mr. F. M. Woodruff, of the Chicago Academy of Sciences, secured a number of postglacial mollusks from marl deposits near Waukesha. This locality is in the northwestern part of Waukesha County, and is well within the area of the Wisconsin ice sheet. The body of water in which the mollusks lived was one of the many small lakes left by the retiring lobes of the Lake Michigan Glacier (Delavan lobe). It has not been possible to correlate this marl bed with any one of the glacial stages of Lake Chicago. Mr. Woodruff reports the shells as very abundant. The following species have been noted:

Amnicola walkeri	*Planorbis campanulatus*
Physa walkeri. Some scalariform	" *antrosus*
Physa warreniana	" *parvus*
Galba nashotahensis	" *exacuous*

Alden[15b] records several mammals as occurring in postglacial deposits in southeastern Wisconsin. They may have been buried during any of the lake stages and a few may belong to recent time.

Cervus canadensis. Antler.
Wauwatosa at depth of 4 feet.
Mammut americanum. Tusk and other bones.
Racine County, Dover township, in well.
Elephas primigenius. Bones and upper jaw.
Milwaukee at depth of 13 feet.

[15a] Smith Contr. to Knowledge, XV, Act. 2.
[15b] Professional Paper 106, U. S. G. S., pp. 346-347.

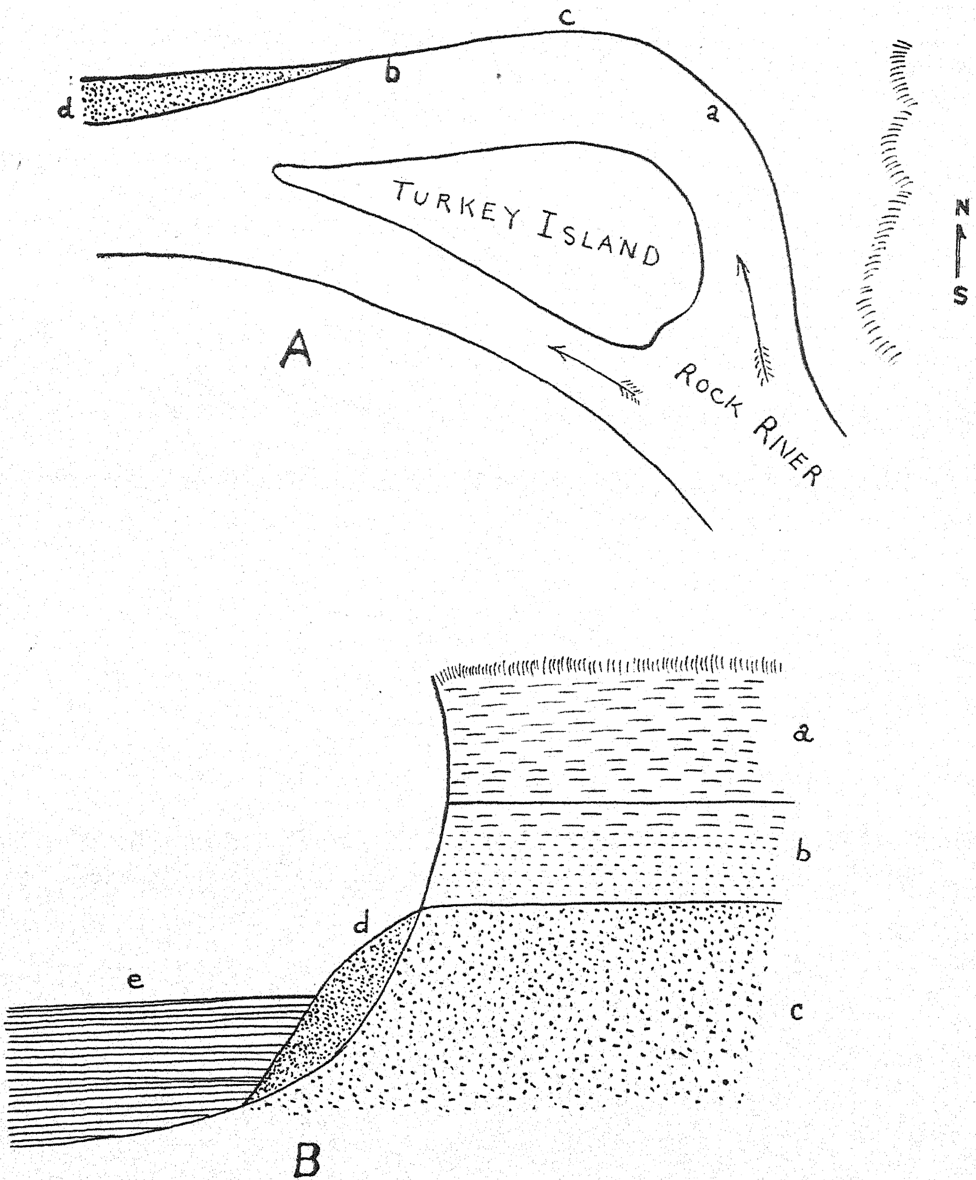

Figure 2. Diagram illustrating terrace deposits on Rock River.

A. Ground plan of river; a-b, points between which section was taken; c, point near which section was taken; d, sand bar on which fossil shells are deposited after being dug from bank by river.

B. Section of terrace at c in A. a, fine rich black alluvium, 3 feet thick, containing shells of *Polygyra* (*Mesodon*), *Succinea*, *Lymnaea*, *Physa*, etc., almost exclusively Pulmonata; b, mixture of top and under stratum, 2 feet thick, containing also a mixture of both kinds of mollusks; c, pure sand and fine gravel, 4 feet thick, containing great numbers of fresh water Mollusca, as *Unio*, *Sphaerium*, *Pisidium*, *Campeloma*, *Pleurocera*, *Amnicola*, *Pyrgulopsis*, *Somatogyrus*, etc.; d, loose sand; e, Rock River (Copied from Shimek, Bull. Lab. Nat. Hist. State Univ. Iowa, II, plate XIII).

Undetermined proboscidians.

Near Madison, teeth and small bones; Fond du Lac, small leg bones in ditch; Lake Monona, Madison, vertebra.

II. ILLINOIS

An account of the lake stages, with their attendant life, has been given in Chapters II and III. Outside this lake basin there are many records of life which are referable to post-Wisconsin time, but which cannot be definitely placed in any one of the lake stages. These may be considered under two heads; 1, fluviatile, and 2, terrestrial.

1. Fluviatile Deposits

Shimek[16] has described a deposit of shells near Rock Island, in a terrace north of Turkey Island. The terrace is said by Leverett[17] to be of Wisconsin age. The diagrams in figure 2 indicate the position and sequence of the strata and the location of the section. Shimek[18] believes that C was evidently an old sand bar upon which were heaped the shells while it lay in the path of a strong current, this supposition being indicated by the coarseness of the material. The middle stratum was deposited while strong currents of flood times alternated with the more sluggish currents of low water and we find a consequent commingling of coarse and fine material. The upper deposit containing carbonaceous material was deposited during floods when silt-laden water backed up and overflowed the land after the river had receded from the old sand-bar. The upper deposits are somewhat loess-like in character. As shown by Leverett, this terrace is of wide extent. Shimek made borings 40, 50, and 150 feet from the edge of the bank and found the sections substantially the same as the river bank section. This deposit was probably contemporaneous with an early stage of Great Lake history, perhaps correlative with the Calumet stage, and certainly as early as the Toleston stage. As indicated in the diagram the lower deposits contain fluviatile life only, while the upper deposits are made up mainly of terrestrial life. The absence of Unios, other than fragments, is noteworthy. The upper stratum represents a period of time somewhat later than the lowest stratum, indicating that the volume of water was much less.

Fluviatile species, mostly from stratum C[19]

Unio, fragments	*Pyrgulopsis scalariformis*
Sphaerium striatinum	*Somatgyrus subglobosus*
" *simile(=sulcatum)*	" *integer*
Pisidium abditum	*Pomatiopsis lapidaria*

[16] Bull. Lab. Nat. Hist. State Univ. Iowa, II, pp. 170-171.

[17] Illinois Glacial Lobe, plate VI.

[18] *Op. cit.*, pp. 173-174.

[19] The newer nomenclature is used in these lists. The species here listed as *coarctatum* was possibly a form of *exilis; coarctatum* is a southern species.

Pleurocera subulare
Amnicola limosa
" *cincinnatiensis* (=*sayana*)
" *emarginata* (=*Bythinella obtusa*)
Valvata tricarinata
" *bicarinata*
Vivipara intertexta
Campeloma subsolidum
" *coarctatum*

Pulmonate species, mostly from stratum A

Polygyra multilineata
" *profunda*
" *clausa*
Vitrea hammonis
" *indentata*
Zonitoides arborea
" *minuscula*
Succinea ovalis (=*obliqua*)
" *avara*
Bifidaria contracta
Bifidaria pentodon
Galba reflexa
" *caperata*
" *obrussa* (=*desidiosa*, of authors)
" *humilis modicella*
Segmentina armigera
Planorbis trivolvis
" *parvus*
Physa gyrina
Ancylus rivularis

The strata described by Tiffany[20] at Rock Ilsand evidently represent the same period as the above deposits described by Shimek. "The locality is situated at the western extremity of the arsenal grounds and the shells were discovered in an excavation 300 feet long and 8 feet deep. Three feet from the top (which is 18 feet above the highest level of the river) is a deposit of shells, mostly Unios, with *Campeloma subsolidum*, and two species of *Helix*. The shell bed is from 6 to 16 inches thick. Human remains were found in the lower part of the shell bed, associated with antler of elk or deer and part of shin bone of Bison(?)."

Shell beds referable to the same period (post-Wisconsin) as those described by Shimek and Tiffany, are reported from the vicinity of Davenport, Iowa,

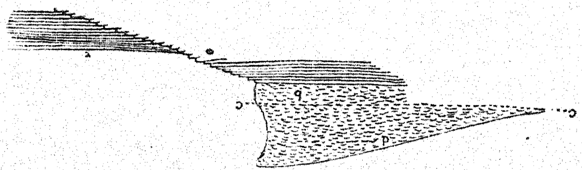

Figure 3. Diagram of shell bed at head of Rock Island. o, Bed of limestone; b, shell bed; c c, general surface; r, river (After Pratt, Prac. Daven. Acad. Sci., II, page 161, fig. 16).

and Rock Island, Credit Island, Gilbert, Moline, and New Boston, Illinois. These beds are from 1–1½ to over 3 feet in thickness, and range in position from just above high water mark to about 5 feet above high water. A section at the head of Rock Island is diagrammatically pictured by Pratt in figure 3. The shell beds lie immediately above the bed rock (limestone) and are covered by deposits brought down by the river. Pratt[20a] lists a number of fluviatile mollusks, but ascribes the shell beds to the agency of modern ice which he believes has pushed them from the river bed to their present location. While this agency does perform such feats with boulders and other objects, it is totally

[20] Proc. Daven. Acad. Sci., I, pp. 42-43.
[a] Proc. Davenport Acad. Sci., II, pp. 156-162.

inadequate to account for the present shell stratum. The deposits are evidently the same as those described above by Tiffany. Thirteen fluviatile and four land mollusks are listed by Pratt.

Fusconaja undata (=*trigonus*)	*Obovaria ellipsis*
Crenodonta plicata	*Nephronajas ligamentina*
Quadrula pustulosa	*Vivipara subpurpurea*
" *metanevra*	*Campeloma subsolidum*
Rotundaria tuberculata (=*verrucosus*)	*Polygyra profunda*
Plethobasus aesopus	" *thyroides*
Elliptio crasidens	" *multilineata*
" *gibbosus*	*Pyramidula alteranta*
Obliquaria reflexa (=*cornutus*)	

Limnaea (*Galba*) *tazewelliana* and *Pyrgulopsis scalariformis*, described by Wolf[21] from post-Pliocene deposits on the Tazewell side of the Illinois River, are probably referable to the same age as the Rock Island fauna. No fossil species other than the *Lymnaea* (now known as *Galba parva*) and the *Pyrgulopsis* have been recorded from this locality, altho they are doubtless to be found in the same deposits. Leverett[22] reports "molluscan shells in sand at 6-10 feet" from section 3-4, T.33, R.5E, LaSalle County, but the nature of the shells is not stated.

Near Mahomet, Sangamon County, on the Sangamon River, fresh-water mollusks have been collected by Dr. T. E. Savage, of the University of Illinois, in a sand stratum about four feet below the surface. The species, 8 in number, are mostly fluviatile, and are listed below:

Unio, fragments	*Amnicola limosa porata*
Sphaerium solidulum	*Pleurocera elevatum*
Pisidium compressum	*Planorbis antrosus*
Campeloma integrum (young)	*Pyramidula solitaria*
Valvata tricarinata	

About three-quarters of a mile below Mahomet, on the north bank of the Sangamon River, a sand stratum occurs in the flood plain of the river, about 8-12 inches below the surface of the river and five feet above the level of the water (in July). The deposit is several hundred feet in extent and is evidently somewhat younger than the deposit examined by Savage. The species collected from this stratum are noted below:

Sphaerium sulcatum	*Valvata bicarinata*
" *stamineum*	*Amnicola limosa*
" *solidulum*	*Pleurocera elevatum*
Pisidium virginicum	*Planorbis antrosus*
" *compressum illinoisesnse*	" *campanulatus*
Campeloma integrum	*Pyramidula alternata*

[21] Amer. Journ. Conch., V, p. 198.
[22] Illinois Glacial Lobe, p. 640.

Mr. J. L. Tunison, of the Page Engineering Co., Chicago, has brot to the writer's attention an interesting deposit situated one mile from Cary, McHenry Co., near the Fox River. The section shows the strata indicated in the table below:

1. Black loam	2½	feet
2. Brown earth	2½	"
3. Marl	4	"
4. Moss	2	"
5. Marl	2	"

The two marl beds and the moss bed contain the remains of life. Stratum 3, the first marl, contains six species of mollusks, as noted below:

Valvata tricarinata	*Amnicola lustrica*
Valvata lewisii	*Planorbis parvus*
Amnicola limosa	*Planorbis exacuous*

The moss bed, stratum 4, is an almost solid mass of vegetable matter. Dr. E. W. Berry, of Johns Hopkins University, examined some of the material and reported as follows: "The moss layer between two layers of marl is certainly very interesting, illustrating as it does changes of level. The form is a sub-species of *Plagiothecum denticulatum* (Linné) B. & S., probably near the subspecies *rosaceum* (Hampe) B. & S. This moss is very common and widespread in middle latitudes and may possibly be a composite form. It grows in various moist (not necessarily swamp) situations from the Atlantic to the Pacific."

The marl beneath the moss, stratum 5, contained but one species of mollusk, *Galba galbana*, a species characteristic of the colder period following the retreat of the ice sheet. The cause of the changes of level in the body of water in which these animals and plants lived is not at present known.

a. Lake Kankakee

Leverett[23] and others have shown that a lake once occupied a large part of the Kankakee marsh area, and Bradley,[24] a number of years ago, reported species of *Unio* and *Paludina* (=*Campeloma*) from sand banks along the Iroquois River, 15-30 feet high, which he believed were made by an old lake. This lake is believed to have been very shallow and there is no reason to doubt the possibility of a biota migrating up the Illinois River and occupying this old lake basin, even while the ice was not many miles away. A careful study of this basin would no doubt reveal many evidences of Pleistocene life.

[23] Illinois Glacial Lobe, pp. 328-338, plate VI.

[24] Geol. Ill., IV, p. 227.

b. Small Lakes

Many small lakes and streams have become filled up since the beginning of post-Wisconsin time. The proof of the existence of these ancient lakes is in the remains of mollusks and other animals which are now embedded in the clay which fills them. In Iroquois County,[25] six miles northwest of Hoopston, a mastodon was found in a bed of clay, associated with the following mollusks:

Planorbis parvus	*Pisidium*, resembling *abditum*
Valvata tricarinata	*Valvata*, resembling *V. striata*(=*lewisii*).

Two miles southeast of Fairmount,[26] Vermilion County, the shells of *Lymnaea*, *Physa*, *Pianorbis*, and *Sphaerium* occur in a light brown tenaceous clay beneath one or two feet of black soil. A mastodon was secured from this deposit; it was lying upon and partly embedded in the marly clay. The location is in an old slough.

On the Champaign till sheet, near the inner side of the Champaign moraine several marl deposits occur which represent the bottom of old ponds which filled kettle holes. Such deposits occur near the new greenhouses at the University of Illinois, Urbana, Champaign County. The fauna, which is quite extensive, indicates a climate colder than at present in this latitude, several of the species now living far to the north of this locality, viz., *Galba obrussa decampi*, *Valvata sincera*, *Pisiidum tenuissimum calcareum*, and *Pisidium costatum*. Collected by Dr. T. E. Savage.

Section of strata on the University Campus, Urbana

4. Top soil or black clay without pebbles, grading into number 3 below	20–24 inches
3. Clay, dark above, becoming light gray and more calcareous below; containing numerous shells of gastropods	18–20 inches
2. Marl or limestone composed of more or less completely broken shells somewhat consolidated by cement of $CaCO_3$	8–12 inches
1. Glacial till, pebbly, gray; the Champaign till sheet, early Wisconsin	6–12 inches

The character of the shells and the position of the shell bed above the till sheet leads to the inference that the pond may have contained the living shells when the late Wisconsin ice was retreating in the northern part of the State. The 20 species observed in this deposit are listed below:

Sphaerium rhomboideum, rare
" *occidentale*, rare
Musculium truncatum, common
" *rosaceum*, rare
Pisidium adamsi affine, rare
" *cf. contortum*, rare
" *costatum*, common

[25] Collett, Dept. Geol. Nat. Res., Indiana, 2nd An. Rep., p. 386.
[26] Bradley, Geol. Ill., IV, p. 242.

Pisidium tenuissimum calcareum, abundant
" *variabile*, rare
" *vesiculare*, not common
Valvata tricarinata, not common
" *sincera*, common
Physa gyrina, abundant
" *sayii*, rare
Planorbis trivolvis, abundant
" *parvus urbanensis*, not common
" *altissimus*, not common
Galba reflexa, abundant
" *caperata*, abundant
" *obrussa decampi*, common

2. *Terrestrial Deposits*

Many years ago,[27] portions of a mastodon were found in a boggy swale near a salt lick, while grading a branch of the C. B. and Q. Railroad at Aurora, Kane County. The tusk was eight feet in length. Bannister[28] republishes this record and adds one for *Castoroides ohioensis*, which was found in a slough near Naperville, DuPage County. Lathrop,[29] long ago, reported a mastodon tooth from the Kishwaukee River, which had been drawn up in a seine. It is impossible to say from just what formation it may have originated.

A mastodon was found at Turner's strippings,[30] about three miles east of Morris, Grundy County, under 18 inches of black mucky soil, and about four feet of yellowish loam, and resting on about a foot of hard blue clay which covered the coal. The location is in a portion of the old river bottom and the body may have been mired here or possibly it was deposited by the river. A skeleton of *Castoroides ohioensis*[31] was found in a ploughed field many years ago near Charleston, Coles County.

In addition to the above, Miss Anderson records a number of proboscidian remains from post-Wisconsin deposits, as indicated below:[32]

Cook County. Evanston, in gravel pit (mammoth); Glencoe, in glacial drift (mastodon)
DuPage County. Wheaton, in ditch on farm (mammoth)
Edgar county. Bottoms of prairie slough, associated with fresh water shells, in light brown marly clay (mastodon); fragments of this animal are not rare in Edgar County.
Grundy County. In bog spring, 7 feet below the surface, associated with bones of bison, deer, and elk (mastodon in abundance). Elephant bones also found in wells in the neighborhood.
Kane County. In marsh, 5 feet below the surface, associated with bison and other bones (mastodon).

[27] Evans, Proc. A. A. A. Sci., V, p. 58.
[28] Geol. Ill., IV, p. 113.
[29] Amer. Journ. Sci., (ii), XII, p. 438.
[30] Bradley, Geol. Ill., IV, p. 193.
[31] Leidy, Proc. Phil. Acad., 1867, p. 97.
[32] Augustana Library Publications, No. 5

Knox County. From recent deposits near the surface (tusk of mammoth); on farm (elephant tooth).
Macon County. Location unknown.
Ogle County. In bog (mammoth).
Vermilion County. Near Danville, in bluff, the following succession of strata occur: Soil, five feet; gravel, with bones of an elephant, eight feet; clay, two feet; fine sand on coal measures, two feet; Near East Lynn, in ditch.

A number of the records of Miss Anderson cannot be included because of the uncertainty of the horizon from which they came. Bagg[33] adds several records to those of Miss Anderson, as follows:

Vermilion County, near Rossville, on the bank of north Fork of Vermilion River, near Pesotum, on farm, 3½ feet below surface.

Kane County, near Maple Park, 6 feet below surface.

The remains of several species of mammals have been found in early Wisconsin deposits in Champaign County. These are now in the Museum of the University of Illinois and were identified by Dr. O. P. Hay. They are all apparently referable to post-Wisconsin time.

Bison bison. Horn cores and part of the skull of a bison were collected at Homer by R. M. Bagg.

Symbos cavifrons. Horn cores and part of the skull of this musk-ox were found in digging a ditch four miles south of Bondville.

Mammut americanum. A lower last molar, which had not been cut in the animal's jaw before its death, was found while excavations were being made for the lake at Crystal Lake Park, Urbana. The deposit was about 200 feet north of the former stream channel, in very low ground.

Megalonyx cf *jeffersonii.* "A claw was found just east of the road and just north of where the old channel was located at the eastern end of Crystal Lake, Urbana. It was found in blue clay excavated from the lagoon west of the road, during the fall of 1909, by Mr. Lindley of Urbana" (C. C. Adams).

3. *Loess Deposits*

Loess deposits overlying Wisconsin till are reported by Barrows[34] from the Illinois Valley. The presence of mollusks is indicated but no species are named Leverett refers to loess shells as follows:[35] "The portion of the Shelbyville moraine north of Shelbyville carries a larger amount of surface silt than the portion east of that city. Not only the moraine but the district to the east, for a distance of perhaps 20 miles, has a coating of silt so thick that bowlders are completely concealed, for it not infrequently reaches a depth of 5 or 6 feet. . . . The silt is usually of a brownish-yellow color, much like that of the oxidized till underneath it, though slightly paler than the till. . .

[33] Univ. Ill. Studies, III, No. 2, pp. 45-56.
[34] Bull. 15, Ill. Geol. Surv., p. 48.
[35] Illinois Glacial Lobe, p. 198.

Where thickest it is somewhat calcareous in the lower portion and carries small molluscan shells of land and water species, similar to those found in the Iowan loess."

III. INDIANA

1. Lacustrine deposits

Records of lacustrine deposits in Indiana are exceedingly rare, that of W. M. Mills[36] being the only reference observed. Near Winona Lake, Kosciusko County, the shells of Unios and univalve mollusks have been found near an ancient beach ten or more feet above the present level of the lake. The shells, with vegetable remains, are on peat bogs, from one-fourth to one-half mile from the present edge of the lake. The old beach in the embayment is 18 to 20 feet above present level. The deposit at the head of the embayment is three quarters of a mile from the shore. It is thot that the lake was held up by two ancient glacial dams. The species of mollusks are not given and their general character can only be guessed. Indiana contains a large number of lakes, many of them with marl beds, which doubtless contain large numbers of mollusks referable to post-Wisconsin time. *Galba galbana* is in the United States National Museum, received from marl deposits three-fourths of a mile southwest of Stewartsville, Posey County, and one and one-half miles northwest of Petersburg, Pike County.

2. Terrestrial Deposits

Records of terrestrial animals are numerous from Indiana, but they cannot be referred to any definite lake stage, altho nearly all are post-Wisconsin. In Randolph County both the mastodon[37] and *Castoroides*[38] have been found, the latter a few miles east of Winchester and the mastodon near Losantville, in a peat bog. The *Castoroides* was in a swamp, about eight feet below the surface, in a bluish gray silt underlying four or five feet of alluvium very rich in vegetable mold, and overlying drift gravel. *Castoroides* is also reported by the same author from Greenfield, Hancock County.[39]

Wabash and Grant counties have furnished, perhaps, a larger number and variety of fossils than any other county in the state. Moses and Benedict have recorded the following species from Wabash County:[40]

Elephas primigenius, in Pleasant Township, under five feet of muck; also near Dora.
Mammut americanum, two miles west of Laketon, in ditch on farm near Silver Creek.

[36] Indiana Dept. Geol. Nat. Res., XXVIII, pp. 377-396.
[37] Moore, Proc. Ind. Acad. Sci., 1896, p. 277.
[38] Moore, Proc. A. A. A. Sci., XXXIX, p. 265.
[39] Proc. Ind. Acad. Sci., 1899, pp. 171-173.
[40] Indiana Dept. Geol. Nat. Res., 17th An. Rep., pp. 240-241.

Cervus canadensis, antlers found in swamp near west county line.
Odocoileus virginianus, 3½ miles north of Roann, in ditch at depth of 9 feet.

In Grant County,[41] four miles east of Fairmount, in a drainage canal which empties into the Mississinewa River, at a depth of 12 to 15 feet, was found a nearly complete skeleton of *Elephas primigenius*. Near this locality a partial skeleton of *Castoroides* was also found. Three miles west of the town of Crown Point, Lake County, near the remains of an old beaver dam, the bones of a mastodon were found some years ago.[42] In DeKalb County[43] the mastodon has been found in five different places. This animal is also reported from near Muncie, Delaware County[44] and an *Elephas* (listed as *primigenius*) is recorded as having been found in the bed of Black Creek in Montgomery County.[45] *Symbos cavifrons*, associated with the mastodon, is recorded from the bottom of Beaver Lake, just east of the Illinois State line in Newton County.[46] Blatchley[47] reports the mastodon, elephant, and other mammals from northwestern Indiana, at the following localities:

Mammut americanum. Kankakee marsh, section 25 (33 N. 7 W.), three miles southeast of Hebron; in a marsh by the side of Cobb's Creek, east of Hebron; near Sandy Hook Creek, northwest of Kouts, 2 feet below the surface; on farm of Peter A. Blair, southwest quarter of section 27 (35 N. 6 W.), two miles southwest of Valparaiso; all, in Porter County.

Elephas (species not definitely ascertained, but listed as *primigenius*). Marsh on head waters of Deep River, north half of section 35 (35 N, 9 W,), about two miles east of St. Johns, Lake County.

Cervus canadensis. Near Sandy Hook Creek, northwest of Kouts, Porter County, associated with mastodon teeth. Antlers of the elk have also been found in Lake County.

Four miles southeast of Noblesville, Hamilton County, the bones of a mammoth were found in a ditch, in fine blue clay under three feet of peat bog.[48] Cope and Wortman[49] list the following species from post-Pliocene deposits, apparently referable to post-Glacial time.

Canis latrans, Boone County, with mammoth.
Platygonus compressus, Laketon, Wabash County.
Castoroides ohioensis, Carroll and Kosciusco counties.

Dr. O. P. Hay[50] records a large number of vertebrates from the post-Wisconsin deposits of Indiana. These are represented in most cases by a few bones

[41] Hay, Smith. Miscel. Coll., LIX, No. 20, p. 13, 1912.
[42] Ball, Proc. Ind. Acad. Sci., 1894, pp. 54-57.
[43] Dryer, 16th An. Rep., Dept. Geol. Nat. Res. Ind., p. 104.
[44] Phinney, 11th An. Rep. Dept. Geol. Nat. Res. Ind., pp. 131-132.
[45] Thompson, 15th An. Rep. Dept. Geol. Nat. Res. Ind., p. 159.
[46] Bradley, Geol. Ill., IV, p. 229.
[47] Geol. Lake and Porter Counties, Indiana, p. 90.
[48] Collett, Ind. Dept. Stat. and Geol., 2nd An. Rep., p. 386.
[49] Dept. Geol. Nat. Res. Ind., 14th An. Rep., part 2.
[50] Ind. Dept. Geol. Nat. Res., 36th An. Rep., pp. 539-784.

or teeth, and rarely by a nearly perfect skeleton. In a few cases the strata in which the bones were found are of uncertain age. Those records not included in the previous pages are listed below:

Cervus canadensis (pages 618–618).

Rensselaer, Jasper County; Foresman, Newton County; North of Camden, Penn Township, Jay County, with mastodon; One or two miles southwest of Winchester, Randolph County; Franklin City, on Nolans Fork, Wayne County; One mile northeast of Cambridge City in Little Simond's Creek, in bed of gravel (may be of recent epoch).

Symbos cavifrons (pages 638–639).

Six miles east of Hebron, Porter County, seven feet deep beneath sand and clay; Randolph County; From bank of White River, near Walesboro, Bartholomew County, near margin of Wisconsin drift.

Ovibos moschatus (pages 641–644).

Near Richmond, Wayne County.

Mammut americanum (pages 700–715).

The mastodon was evidently widely distributed in Indiana during post-Wisconsin time, judging from the number and the wide dispersal of its remains. Hay reports it from the following localities:

Allen County; Fort Wayne. Dekalb County; Waterloo, in peat bog, 5 miles west of town. Fountain County; in wet prairie; Newton, in bank of coal Creek, 3 feet beneath surface. Franklin County; Brookville, in peat. Grant County; lake marsh in Fairmount Township. Hendricks County; near Danville. Henry County; (no data). Jackson County; Sparksville, in bank of White River. Jasper County; in peat. Lay County. LaGrange County; near LaGrange. Madison County; near Anderson, in swamp, under 3 feet of soil. Marion County; Indianopolis, corner Pennsylvania and 30th Street, in sewer. Marshall County; south of South Bend, in ditch near line between Marshall and St. Joseph counties. Miami County; Denver, under 5-6 feet of muck. Montgomery County; on farm in section 12, T.20 N.R. 3. W. Newton County; in Beaver Lake. Parke County; junction of Raccoon and Little Raccoon creeks. (The horizon to which this record should be assigned is doubtful.) Porter County; on Valparaiso moraine, 8 feet below surface, five miles southwest of Valparaiso. Putnam County; near Greencastle (no record of geological strata). St. Joseph County; Kankakee marsh, Olive Township, ten miles west of South Bend; also in Portage Township. Steuben County; near Ashley, in swamp 5 feet below surface, in marl overlaid by muck. Tipton County; near Lancaster, in black soil, underlaid by white marl. Wabash County; Township 29, R. 7, three miles east of North Manchester. Wayne County; two miles east of Richmond in fish pond; Jacksonburg, eighteen miles west of Richmond; Dalton, on Nettle Creek.

Elephas primigenius (page 733).

Jefferson County; Randolph County, near Windsor, in bed of Stoney Creek; St. Joseph County, Liberty Township, sixteen miles southwest of South Bend.

Elaphas columbi (pages 742-746).

Carroll County, Bringhurst; Monroe County, Gosport, in bank of White River, at depth of 8-9 feet, in bed of sand overlaid by plastic bluish clay. Thot by Hay to be alluvium of valley laid down during or after the Wisconsin invasion (page 744); Morgan County, 1½ miles west of Monrovia, on gravel bar in Sycamore Creek; Tipton County, Windfall.

Mammoth remains, species not indicated (pages 746-750).

Allen County; Dubois County (age doubtful); Jasper County ?; Martin County, imbeded in marsh clay resting on drift; Parke County; Putnam County; Vermilion County; Vigo

County, farm in Otter Creek Township; Wabash County, east half section 18.T. 27.R. 8, near Dora, Pleasant Township, under 5 feet of muck; Wayne County, on Nolans Fork, near Webster.

Castoroides ohioensis (pages 766-768).

Boone County, no locality; Cass County, 2-3 miles south of Logansport, 7 feet below surface, lying on fine sand, covered with 1 foot of solid gravel, 3 feet of clay and 3 feet of alluvium; Grant County, near Greenville; Madison County, near Summitville; Wayne County, two miles east of Richmond, in fish pond with decayed mastodon bones.

IV. MICHIGAN

Several deposits have been observed in Michigan which contain an abundance of molluscan life. Some of these deposits are referable to the Lake Warren, Lake Algonquin, and Nipissing Great Lakes stages. Others are of uncertain age, tho all are postglacial and pre-recent.

1. Lake Warren

Near Badake, in Huron County, (section 24) alternating beds of marsh and marl deposits (two beds of each) have been observed. In section 32, close to the stone wall, marsh deposits also occur.[51] The deposits first mentioned are 760 feet above tide or about 180 feet above the present level of the lake. They are referred by Lane to the Forest beach of Lake Warren. The species contained in the two lower deposits are as follows:

Sphaerium simile (=*sulcatum*)	*Valvata tricarinata*[52]
Musculium secure	*Physa ancillaria*
Pisidium abditum	" *gyrina*
" *compressum*	*Ancylus* species
" *variabile*	*Planorbis antrosus*
" *contortum*	" *campanulatus*
" *contortum*, var.	" *deflectus*
" *rotundatum*	*Galba obrussa*
" *scutellatum*	*Galba* species[53]
Amnicola limosa	*Zonitoides arborea*

2. Lake Chicago (Toleston Stage)

Two miles west and a little north of Buchanan, Berrien County, is a stretch of low land known as Bakertown marsh. The marsh was previously a lake about three miles long and a mile wide, but is now grown up in marsh grass and is practically dry. A ditch about a mile in length drains the marsh and exposes the strata, as noted below:

VIII	Marsh bog..............................	16 inches
VII	Recent peat............................	20 "

[51] Geol. Surv. Mich., VII, part ii, p. 247.

[52] Evidently includes *tricarinata* and its varieties. Walker says, "exhibiting all stages from the unicarinate to the tricarinate form,—none ecarinate."

[53] Imperfect specimens, lacking the spire.

VI	Peat and drift wood	10 "
V	Lake silt (no shells)	8 "
IV	Semi-ligneous peat	12 "
III	Shells and lake drift	8 "
II	Blue clay	7 "
I	Quicksand	7 to 10 feet

The thickness of the sedimentary deposits above the sand is 81 inches or 6 feet 9 inches. The quicksand (stratum I), perhaps, represents the period of Lake Dowagiac when the glacial waters drained into the Kankakee River, loaded with sediment (Plate XLVII, Fig. 1). The clay (stratum II) may represent a quieter stage, after the main drainage had shifted to the Chicago outlet (Plate XLVII Fig. 2). Stratum III probably represents the bottom of a larger St. Joseph River, for the species of naiads in this deposit are mostly of the river type. An arm of Lake Chicago extended up the St. Joseph River from Benton Harbor to about the vicinity of Berrien Springs[54] and the river drained into this extension of Lake Chicago.

The fluviatile mollusks could have reached this locality from two sources: (1), by way of the Chicago outlet, across Lake Chicago and up the St. Joseph River; and (2), by way of the Kankakee River when it was connected with the St. Joseph and Dowagiac rivers at South Bend. The mussels are mostly of the river type and their natural migration route would be by way of a river. Just how long after the formation of Lake Chicago the St. Joseph-Kankakee drainage persisted is not definitely known, but it is believed to have continued for some time in a more or less modified form. The naiades represent a climate fully as warm as the present and they probably would not invade the waterways of an icy drainage. Certain boreal types of mollusks could and evidently did take advantage of this waterway at an early stage. It is possible that both drainages were used and the fauna may represent a mixture of the two migrations. This stratum would seem to correlate with the Toleston stage of Lake Chicago and may include, also, some deposits made during the Calumet Stage.

The five and a half feet of silt and peat above the shell deposit represent the later stages of this locality and indicate its change from a river to a lake and finally to its present marsh-bog character. Stratum IV indicates a period of low water between higher water—lake or river—conditions. The Mollusks (42 species) and other remains of life in the shell deposit are listed below:[55]

Lasmigona compressa (=*pressus*)	*Pleurocera elevatum*
" *costata* (=*rugosa*)	*Goniobasis livescens*
Anodonta grandis footiana	*Valvata tricarinata*
Anodontoides subcylindraceus	*Amnicola limosa*
Alasmidonta calceola (=*deltoidea*)	" *lustrica*

[54] See Leverett, Illinois Glacial Lobe, plate XV.
[55] Walker, Nautilus, XI, p. 121; XIII, pp. 34, 55.

Eurynia iris (=*novi-eboraci*)	*Physa ancillaria*
" *ellipsiformis*(=*spatulatus*)	" *integra*
Lampsilis ventricosa	" *heterostropha*
Sphaerium simile(=*sulcatum*)	*Ancylus rivularis*
" *striatinum*	*Planorbis antrosus*(=*bicarinatus*)
Pisidium near *abditum*	" *campanulatus*
" *compressum*	" *trivolvis*
" *medianum*	" *deflectus*
" *milium*	" *parvus*
" *pauperculum*	*Galba obrussa* (=*desidiosa*, authors)
" *roperi*	" *humilis modicella*
" *ventricosum*	*Lymnaea stagnalis appressa*
" near *vesiculare*	*Carychium exiguum*
Campeloma integrum	*Succinea ovalis*
" *integrum obesum*	*Strobilops labyrinthica*
" *subsolidum*	*Vitrea hammonis* (=*radiatula*)
Head of dipterous insect	*Mammut americanum*

Considerable drift wood was observed, but none was identified. The shells occur in little colonies, just as they are found today. It is probable that these colonies represent localities where the water had brot together and deposited a quantity of dead shells, drift wood, and other debris, and not colonies of living mollusks. The mastodon skulls were found in and under the stratum of semi-ligneous peat, showing that these animals waded into the river after the shells were deposited. They were probably caught in the boggy marsh and drowned.

3. *Lake Algonquin*

In Fairhaven Township, Huron County, in a bog near the corner of sections 26 and 27, sands occur which lie at an elevation of a little more than 20 feet above the lake level (605 feet above tide). On the north side of section 34, deposits occur which are thot to be fragments thrown up on the beach. They are somewhat higher than the deposits previously mentioned. Both are referred to the Lake Algonquin stage. The molluscan remains in these deposits are tabulated below:

Elliptio gibbosus	*Campeloma* species
Sphaerium striatinum	*Planorbis campanulatus*
Pisidium contortum	" *deflectus*
Goniobasis livescens	" *antrosus* (=*bicarinatus*)
Amnicola limosa	

Extensive deposits occur in Bay County which contain much biotic material.[56] Several of these are referable to the Lake Algonquin stage. "Near the northeast corner of section 33, near Monitor, is a depauperized fauna in a sandy loam deposit containing cobble stones. The she ls are well preserved. The area was occupied by a swamp land formed back of the Algonquin beach to

[56] Cooper, Rep. State Board Geol. Surv. Mich., 1905, p. 353.

the eastward. The elevation is about 601 feet"; 14 species are recorded from this locality.

Musculium secure	*Galba obrussa* (=*desidiosa*)
Pisidium contortum	" *palustris*
" *rotundatum*	*Physa elliptica*
" *scutellatum*	*Planorbis parvus*
" *variabile*	" *trivolvis*
" *ventricosum*	*Succinea retusa*
" *ventricosum costatum*	*Valvata sincera*

Sand deposits thot to be of Algonquin age occur in a cut between section 24 and 25, in Spaulding Township, Saginaw County.[57] The following species have been identified:

Unio species	*Physa gyrina*
Sphaerium simile (=*sulcatum*)	" *elliptica*
Pisidium compressum	*Planorbis antrosus* (=*bicarinatus*)
" *variabile*	" *campanulatus*
" *walkeri*	" *trivolvis*
Goniobasis livescens	" *parvus*
Pleurocera species	*Galba palustris*
Amnicola limosa	" *reflexa*
Campeloma integrum	*Lymnaea stagnalis appressa*
Physa species	*Polygyra albolabris*

Some years ago, Mr. A. W. Slocum collected a number of mollusks from marl beds at Oden and Kegomic, Emmet County. Oden lies between the Algonquin and Nipissing beaches, in fact is really on the Nipissing beach, while Kegomic is on the old lake floor. These marl deposits are reported as upwards of sixty feet in thickness, and the deposits, especially at Kegomic, probably represent both the Algonquin and the Nipissing stages. The large lakes, Burt and Mullet, as well as the smaller lakes, Crooked, Pickerel, etc., are relics of the wide strait which, during these lake stages, connected Lake Huron with Lake Michigan and separated portions of Emmet and Cheboygan counties from the lower peninsula, the former territory then being an island, with the Straits of Mackinac on the north. The following species of mollusks have been identified from the two localities:

Oden

Sphaerium striatinum	*Planorbis campanulatus*
Physa niagarensis	*Galba emarginata canadensis*
Planorbis antrosus	*Lymnaea stagnalis appressa*

Kegomic

Sphaerium striatinum	*Pisidium contortum*
Musculium secure	*Physa niagarensis*

[57] Geol. Surv. Mich., VIII, part ii, pp. 97-102. Mollusks are listed from several other localities, but none seem to be from deposits made by the ice-bound lakes, other than those listed.

Pisidium compressum
" *variabile*
" *adamsi affine*
" *medianum*
" *splendidulum*
" *scutellatum*
Ancylus parallelus
Planorbis deflectus
" *campanulatus*
Galba galbana
" *humilis rustica*

Several deposits in Bay County (of doubtful age) are described by Cooper.[58] On the east line of section 23, Hampton Township, extending south from Nebobish Avenue almost to the section corner, the annexed section occurs.

Sand and gravel........................	10-20 inches
Bed of muck	
Clay	

Shells are found in all three strata. Cooper believes that the region was a swamp during Nipissing or late Algonquin time; 15 species of mollusks occur.

Elliptio gibbosus?
Sphaerium flavum
" *simile(=sulcatum)*
Pisidium adamsi affine
" *compressum*
" *variabile*
" *virginicum*
" *trapezoideum*
Goniobasis livescens
Physa gyrina hildrethiana
Planorbis antrosus
" *trivolvis*
Galba catascopium
" *obrussa decampi*
Succinea retusa

A second locality is on the north line of section 10, Merritt Township, not far east of the northwest corner. In a drain there was four and a half feet of white sand at the top, which was underlaid by a thin layer of muck above the clay. The section was not unlike that at the preceding locality. The deposit of muck is thot to represent late Algonquin or possibly Nipissing time, while the sand is believed to represent Nipissing time. Life is poorly represented here, *Goniobasis livescens* being the only animal seen.

4. *Nipissing Great Lakes*

The three deposits described below are believed to have been laid down during the Nipissing stage:[59]

(1) In a drain about three feet deep on the west line of the northwest quarter of section 7, T. 13 N, R. 5 E, mollusks were found in a silt-clay, either of lake origin or deposited more recently by the river. The elevation is about 587 feet above tide. The assemblage of species suggests that the locality was a lake shore upon which the shells were cast by the waves.

[58] *Op. cit.*, p. 252.
[59] Cooper, *op. cit.*

Sphaerium occidentale	*Planorbis trivolvis*
Pisidium compressum	*Segmentina armigera*
" *scutellatum*	*Galba caperata*
" *variabile*	" *humilis modicella*
Valvata tricarinata	" *palustris*
Goniobasis livescens	*Succinea avara*
Amnicola limosa	" *retusa*
" *walkeri*	*Vertigo* species
Physa elliptica	*Zonitoides minuscula*
Planorbis hirsutus	*Polygyra monodon*
" *parvus*	*Bifidaria pentodon*

(2) Ditch, 12-18 inches deep, on the line between sections 9 and 10, T. 13 N, R. 5 E., south of the quarter post. The deposit is clay containing small pebbles. Specimens were also seen in the same section farther east. During the high water of the spring of 1904, this region was entirely flooded. The area is on the border of the prairie region. The following fauna was obtained from this deposit:

Sphaerium simile	*Planorbis antrosus*
Pisidium adamsi affine	" *campanulatus*
" *compressum*	" *deflectus*
" *medianum*	" *exacuous*
" *sargenti*	" *hirsutus*
" *scutallatum*	" *parvus*
" *splendidulum*	" *trivolvis*
Valvata tricarinata	*Segmentina armigera*
Goniobasis livescens	*Galba caperata*
Campeloma decisa	" *obrussa(=desidiosa)*
Amnicola limosa	" *reflexa*
" *walkeri*	*Succinea retusa*
" *lustrica*	*Polygyra monodon*
Physa heterostropha	" *multilineata*
" *gyrina hildrethiana*	

(3) Muck underlying clay in a ditch on the west line of northwest quarter section 31, Merritt Township. The elevation is 586 to 588 feet above tide. Sixteen species of mollusks have been identified.

Sphaerium flavum	*Physa gyrina hildrethiana*
" *simile*	*Planorbis antrosus*
" *occidentale*	" *campanulatus*
Pisidium compressum	" *deflectus*
" *scutellatum*	" *trivolvis*
Valvata tricarinata	*Galba reflexa*
Goniobasis livescens	*Lymnaea stagnalis appressa*
Campeloma integra	*Succinea retusa*

Mr. Frank B. Taylor (in a letter) reports four species from the Nipissing beach, in gravels, a little below the top, at Cheboygan.

Lampsilis luteola	*Goniobasis livescens*
Sphaerium striatinum	*Galba elodes*

5. Deposits of Uncertain Age

There are a multitude of lakes in Michigan which contain ancient marl beds referable to some one of the lake stages. As these deposits cannot be correlated with any of the known beaches it is impossible to refer them definitely to any period of the lake history. They are probably to be classed as of Nipissing age, tho some may be as old as Algonquin time, or even older. Nearly all of the shell-bearing strata are covered with peat deposits of greater or less thickness, showing that there has been a shallowing of the water since the formation of the lakes.

Russell and Leverett[60] describe a marl deposit beneath 5 feet of peat, in swampy territory three miles south of Ann Arbor, containing mollusks, as well as a skull of *Castoroides*. The species of mollusks are indicated below:

Valvata sincera	*Carychium exiguum*
" *tricarinata*	*Succinea avara*
" *tricarinata confusa*	" *retusa*
Physa ancillaria	*Strobilops affinis*
" *integra*	*Polygyra monodon*
" *gyrina hildrethiana*	*Helicodiscus parallelus*
" *elliptica*	*Pyramidula cronkhitei anthonyi*
Planorbis campanulatus	*Zonitoides arborea*
" *hirsutus*	" *minuscula*
" *exacuous*	*Euconulus fulvus*
" *parvus*	" *chersinus polygyratus*
Galba obrussa decampi	*Vitrea hammonis*

The absence of pelecypods and the presence of so many land mollusks (nearly 50 per cent) is noteworthy. The deposit was either formed in shallow water or near the shore. It is extremely difficult to correlate the age of these deposits with that of any of the lake stages. The swamp is from 820 to 826 feet above the sea, which is several feet above the highest beaches of the ancient lakes. The life may have been contemporaneous with Lake Warren, possibly correlative in time with the formation of the Forest beach.

The presence of extinct mammals in the same deposits is evidence of their comparative antiquity. Bones of the mastodon as well as of *Castoroides* have been obtained and are preserved in the museum of the University of Michigan. Several molar teeth of *Castoroides* were also found between the Ann Arbor Railroad and Packard Street, in meadow land. This same swamp (but in later deposits) has yielded the bones of the elk, deer, and other vertebrates, and we may well conceive that in former times these and other animals frequented this region and became mired in the swampy portions of the lake.

[60] Ann Arbor Folio, p. 9.

The multitude of lakes which dot the surface of Berrien, Cass, and Van Buren counties, especially in the swampy area near the Dowagiac and St. Joseph rivers, nearly all have marl deposits correlative with the later stages of Great Lake history. Some of these may date from the glacial Lake Dowagiac which had its outlet thru the Kankakee Valley, while others are relics of the early stages of Lake Chicago when an arm extended into Michigan and up the valleys of the Pawpaw and Black rivers (Plate XLVII, figs. 1, 2).

In the northwestern part of Cass County, and also partly in Van Buren County, is a lake of considerable size known as Magician Lake. This body of water empties into the Dowagiac River thru Dowagiac Creek. Swampy tracts and old shore lines indicate that this lake was once considerably larger and deeper. On the north shore, near the summer resort and about midway of the lake, is an old embayment which is a swampy terrace about two feet above the water line. The upper three feet are peaty and boggy; beneath this stratum is a marl bed of unknown depth, which is filled with mollusks of the species indicated below:

Unio, fragments	*Physa walkeri*
Sphaerium simile (=*sulcatum*)	" *gyrina*
Pisidium compressum	*Planorbis antrosus*
" *variabile*	" *antrosus angistomus*
" *noveboracense*	" *parvus*
" *splendidulum*	" *deflectus*
" *adamsi affine*	" *hirsutus*
Valvata tricarinata[61]	*Planorbis exacuous*
Amnicola limosa	*Galba palustris*
" *lustrica*	" *galbana*
Paludestrina nickliniana	" *obrussa decampi*
Physa niagarensis	" *obrussa exigua*
" *ancillaria*	*Lymnaea stagnalis appressa*

Of the above 25 species and varieties, 5 species make up about 90 per cent of the bulk of the material. These species are indicated in the order of their abundance.

Valvata tricarinata
Planorbis parvus
Amnicola lustrica
Paludestrina nickliniana
Galba obrussa decampi

Lymnaea stagnalis appressa, *Galba galbana*, and *Physa walkeri* do not live in the lake at the present time. This fauna may have migrated up the St. Joseph River to the Dowagiac River and then up Dowagiac Creek.

In the northeastern part of Berrien County, near the VanBuren County line, is another lake of about the same area as that of Magician Lake. This

[61] Central carina almost absent in some specimens.

body of water drains into the St. Joseph River, thru Pipestone Creek. Marl beds similar to those of Magician Lake occur in Pipestone Lake, from which the mollusks noted below have been obtained:

Sphaerium simile(=sulcatum)	*Planorbis trivolvis*
" *striatinum*	" *antrosus*
Pisidium compressum	" *antrosus angistomus*
" *variabile*	" *antrosus striatus*
" *splendidulum*	" *campanulatus*
Valvata tricarinata	" *deflectus*
Amnicola limosa parva	" *hirsutus*
" *lustrica*	" *parvus.* Many monstroscities
Physa niagarensis	*Galba obrussa decampi*
" *heterostropha*	" *obrussa exigua*
	Lymnaea stagnalis appressa

These mollusks evidently migrated to Pipestone Lake either by way of the Chicago outlet, the St. Joseph River, and Pipestone Creek, or up the Kankakee and St. Joseph rivers. It is probable that both routes contributed to the faunas of these lakes.

Galba bakeri has been described by Walker from a marl deposit in the bottom of Pine Lake, near Charlevoix.[62]

6. *Vertebrate Animals*

A number of vertebrates have been reported from the postglacial deposits of Michigan. A few of these have been noted in the preceding pages. Additional records are listed below. Lane cites the presence of both mammoth and mastodon.[63]

Mammoth. Grand Ledge, Eaton County, one foot from surface in a low swale once a duck pond; Pere Marquette shaft, no. 2, East Saginaw, Saginaw County, 25 feet above the lake, 2½-3 feet below the surface.

Mastodon. Eau Claire, Berrien County, in ditch; Lenawee County and Shiawassee River, in Howell Township, found while dredging river; Hillsdale, Hillsdale County,in swamp;Clinton, Lenawee County; Olivet, Eaton County; Williams Township, Bay County, in deep hole of mucky soil, 3 feet below the surface; Parr, Midland (or Allegan) County.

Many years ago, Winchell[64] listed the following records of the mastodon:

Seven miles from Adrian, Lenawee County, two feet below the surface, in a peaty bog. A section of the bog showed peat 2½ feet, marly clay 4 feet, loose sand at bottom. The balance of the records are without specific data as to stratigraphic location. Petersburg, Monroe County; Utica, Macomb County; Green Oak, Livingston County; Fentonville, Oakland County; Terre

[62] Nautilus, XXII, p. 18, 1908.
[63] Rep. State Board Geol. Surv. Mich., 1901, pp. 252-253.
[64] Amer. Journ. Sci., (ii), XXXVIII, pp. 223-224, 1864.

Coupé, Berrien County (buried six feet beneath the surface).[65] *Elephas jacksoni* (= *E. columbi*) is reported as being found with antlers of the elk and deer.

Additional proboscidian records are given by Wood[65a] as follows:

Elephas columbi. Jackson County.

Elephas primigenius. Jackson, Van Buren, Macomb, and Clinton counties.

Mammut americanum. Wayne, Van Buren, Eaton, Muskegon, Montcalm, Gratiot, Saginaw, Jackson and Shiawassee counties.

Castoroides ohioensis is reported from Lenawee and Lapeer counties, and also from two other recently known localities,[66] near Owosso, Shiawassee County, and in a tamarack swamp in Pittsfield Township, Washtenaw County, lying on a bed of gravelly marl, beneath three feet of peaty soil. *Platygonus compressus* has been reported[66a] from Belding, Kent County, in a peat bog. Five individuals were found.

Bootherium sargenti is reported by Gidley[67] from Moorland swamp, on the Charles McKay farm, near Grand Rapids, in postglacial deposits. Case[67a] records a nearly complete skull of *Symbos cavifrons*, found on the farm of Wm. J. Schlicht, about three miles northwest of Manchester. It lay in a bed of clay four feet below the level of the rather swampy surface and was covered by black muck filled with plant remains, a thin stratum of fine gravel separating the two layers.

V. OHIO

1. *Invertebrate Life*

No data are at hand bearing on the lacustrine or fluviatile life of Ohio that is referable to any of the Great Lakes stages. The beaches along Lake Erie, especially in the old Fort Wayne outlet,[68] should yield good results when carefully examined. In the Geology of Ohio, Volume I pages 488-489, Read mentions a swamp behind an old lake beach at Ashtabula, Ashtabula County, which should contain the remains of lacustrine life.

Sterki[69] lists a number of mollusks from a sandy deposit (perhaps loess) four miles east of Defiance, on the north bank of the Maumee River, at the State dam. Nearly all are pulmonates.

Gastrodonta ligera	*Polygyra fraudulenta*
Zonitoides arborea	" *inflecta*
" *laeviscula*	" *hirsuta*

[65] Lapham, Proc. Bost. Soc. Nat. Hist., V, 133, 1855.
[65a] Wood, Occ. Papers, Univ. of Mich., No. 4, p. 13.
[66] Wood, Science, N. S., XXXIX, p. 759, 1914.
[66a] Wagner, Journ. Geol., XI, p. 777, 1903.
[67] Proc. U. S. Nat. Mus., XXXIV, pp. 681-684.
[67a] Occas. Papers, Zool. Mus., Univ. Mich., No. 13, pp. 1-3, 1915.
[68] See Leverett, Monograph XLI, U. S. Geol. Surv.
[69] Proc. Ohio State Acad. Sci., IV, p. 402.

Vitrea hammonis(=*radiatula*)	*Pyramidula solitaria*
" *indentata*	" *alternata*
Circinaria concava	" *cronkhitei anthonyi*
Polygyra profunda	*Bifidaria contracta*
" *multilineata*	*Succinea avara*
" *albolabris*	" *retusa*, var.
" *zaleta*	*Physa* species (broken)
" *clausa*	*Pomatiopsis lapidaria*
" *mitcheliana*	*Pisidium compressum*
" *thyroides*	*Pisidium fallax*
" *elevata*	*Unio*, fragments

From Holmes County, Claypole[70] has recorded the presence of a fauna which is probably post-Wisconsin. The locality is near Millersburg, which is near the edge of the Wisconsin drift. The deposit was found in a ditch in a swamp. Six feet of peat covered a bed of shell marl, in or on which a *Megalonyx* skeleton was lying. The animal died, it is evident, after the marl had been formed. The upper layers of the marl contain the following species of mollusks:

Valvata tricarinata	*Planorbis parvus*
Amnicola limosa	*Sphaerium simile*
" *limosa porata*	*Pisidium virginicum*

By far the most complete postglacial fauna yet described from marl deposits is listed by Sterki from two localities in northern Ohio. "One locality is in Erie County, a few miles east of Sandusky Bay and a few miles west of Castalia, and appears to be of comparatively recent date, the marl beds possibly still forming at some places. The other locality is in the northeast corner of Summit County, where it was exposed by the dredging of Tinker's Creek. It appears to be covered, at least in part, by several feet of sand and gravel. It is very rich in fossils but its fauna is radicllay different from that of the Castalia locality." It has not been possible to correlate these deposits with any of the stages of the Glacial lakes.

In the Castalia beds there are 75 species and races, 50 of which are land species and 25 are fluviatile species, or 66 per cent land species. In the Tinker's Creek fauna there are but 8 land species and upwards of 45 fluviatile species, or only 15 per cent land species. Of the fluviatile species, only 10 are common to both localities and but one, *Planorbis parvus*, is abundant in both. The presence of *Acella haldemani* and *Lymnaea stagnalis appressa* in the deposit at Tinker's Creek is especially noteworthy, both being rare in Ohio. The lists of species from these localities with notes, prepared by Dr. Sterki, are given below:

Fossil mollusks from Castalia marls
Erie County

Gastrodonta ligera, rather scarce.
Zonitoides arborea, frequent.
Zonitoides minuscula, common to abundant.
Vitrea hammonis, common.
Vitrea wheatleyi, a few.
Vitrea rhoadsi, one not full grown.

[70] Amer. Geol., VII, pp. 122-132, 149-153.

Vitrea indentata, common.
Euconulus fulvus, frequent.
Euconulus chersinus, scarce.
Euconulus sterkii, scarce.
Agriolimax campestris, some shell plates.
Limacid, species indet. One shell plate, 5 mm. long, 3.5 mm. broad, rather thick.
Circinaria concava, rather frequent.
Helicodiscus lineatus, common.
Pyramidula solitaria, scarce.
Pyramidula alternata, rather scarce.
Pyramidula perspectiva, very scarce.
Pyramidula cronkhitei anthonyi, very scarce.
Punctum pygmæum, rather scarce.
Sphyradium edentulum, very scarce.
Polygyra profunda, common, large.
Polygyra multilineata, abundant, one specimen reversed.
Polygyra albolabris, scarce.
Polygyra thyroides, common.
Polygyra pennsylvanica, but one specimen found.
Polygyra palliata, scarce.
Polygyra tridentata, rather scarce.
Polygyra fraudulenta, common.
Polygyra monodon, abundant.
Polygyra hirsuta, frequent.
Strobilops labyrinthicus, rather scarce.
Strobilops affinis, abundant.
Vallonia pulchella, frequent, of fresh appearance, not chalky.
Pupoides marginatus, common, of fresh appearance, not chalky.
Gastrocopta armifera, typical form rather scarce.
Gastrocopta contracta, common.
Gastrocopta pentodon, scarce.
Gastrocopta tappaniana, abundant, mostly of a small, oval form.
Gastrocopta corticaria, very scarce.
Vertigo ovata, rather frequent.
Vertigo morsei, common.
Vertigo elatior, common.
Vertigo tridentata, very scarce.
Vertigo milium, very scarce.
Succinea ovalis, rather frequent.
Succinea retusa, rather frequent, different forms.
Succinea avara, rather frequent, shells fresh, not chalky.
Succinea avara?, form with long, slender spire, apparently distinct; 8-10 mm. long, 4+ whorls.
Carychium exiguum, abundant.
Carychium exile, rather scarce.
Galba reflexa, common, variable.
Galba nashotahensis, frequent.
Galba humilis modicella, rather common.
Galba humilis rustica, frequent.
Galba parva, not common.
Galba dalli, common.
Galba caperata, rather common.
Planorbis trivolvis, abundant.
Planorbis umbilicatellus, two, small and probably immature.
Planorbis parvus, common, rather small with narrow whorls.
Planorbis crista cristatus, scarce.
Segmentina armigera, common.
Ancylus, several species not yet identified.
Gundlachia species, one specimen.
Physa gyrina, common and variable.
Physa integra, rather scarce.
Physa heterostropha?, small with short spire; frequent.
Physa aplectoides, scarce.
Aplexa hypnorum, rather scarce.
Goniobasis livescens, common.
Pomatiopsis lapidaria, fairly common.
Pisidium abditum, frequent.
Pisidium pauperculum, scarce.
Pisidium medianum, very scarce.
Pisidium rotundatum, very scarce (one valve).
Not a trace of Unionidae observed.

Fossil mollusks from Tinker's Creek marls, Summit County, Ohio

Zonitoides arborea, very scarce.
Vitrea indentata, very scarce.
Pyramidula cronkhitei anthonyi, very scarce.
Polygyra profunda, one specimen.
Succinea ovalis, very scarce.
Succinea retusa, very scarce.
Succinea avara, very scarce.
Carychium exiguum, very scarce.
Lymnaea stagnalis appressa, rather scarce.
Acella haldemani, scarce, a few fragments only.

Pseudosuccinea columella, scarce.
Galba humilis modicella, rather frequent.
Galba humilis rustica(?), rather scarce.
Galba obrussa decampi, common.
Planorbis campanulatus, not common.
Planorbis binneyi, very scarce.
Planorbis antrosus, common.
Planorbis exacuous, frequent.
Planorbis rubellus, rather scarce.
Planorbis crista cristatus, scarce.
Planorbis parvus, common, rather variable.
Planorbis albus (=*hirsutus*), common.
Ancylus parallelus.
Ancylus kirtlandi.
Gundlachia species, first stage, one specimen
Physa gyrina, rather scarce.
Physa integra, scarce.
Physa heterostropha (?), scarce.
Physa sayii, large, rather frequent.
Amnicola limosa, common.
Amnicola lustrica, common.
Amnicola emarginata, scarce.
Valvata tricarinata, common.
Valvata sincera(?).
Sphaerium sulcatum, rather frequent.
Sphaerium striatinum, form.
Sphaerium solidulum, scarce.
Sphaerium rhomboideum, very scarce.
Musculium truncatum, rather frequent.
Musculium secure, scarce.
Musculium rosaceum, scarce.
Pisidium compressum, common.
Pisidium fallax, scarce.
Pisidium variabile, frequent.
Pisidium adamsi affine, rather scarce, juvenile to adult represented.
Pisidium abditum, rather scarce.
Pisidium pauperculum, abundant.
Pisidium walkeri, scarce.
Pisidium scutellatum, scarce.
Pisidium ohioense, scarce.
Pisidium splendidulum, frequent.
Pisidium rotundatum, scarce.
Pisidium medianum, frequent.
Fragments of Unionidæ only in a thin top layer which may be of later origin.

2. *Vertebrate Life*

Hay[71] refers the deposit in Holmes County containing the Megalonyx skeleton to post-Wisconsin time, with the following note: "The terminal moraine of the Wisconsin drift sheet runs through the county in an east by northeast direction, and this had led to the formation of a small lake north of it, which finally became a swamp filled up with peat. By some means the *Megalonyx* had left his remains in the lake after the formation of the shell marl and before the growth of the peat. It is evident that this sloth existed after the retirement of the Wisconsin drift-sheet and long enough after it for the climate to become sufficiently warm to permit this animal to wander into Ohio." Dr. Hay also cites *Megalonyx* from Norwalk, Huron County, establishing beyond doubt the occurrence of this giant sloth after the retreat of the Wisconsin ice sheet.[72]

Mastodon remains have been reported from various parts of Ohio. Those referable to post-Wisconsin time are listed below.

Bucyrus, Crawford County, in swamp, embedded in muck and marl.[73] Clay Township, 2½ miles east of St. Johns, Auglaize County, in swamp, under 3 feet of black muck and 5 feet of marly clay;[74] Springfield, Lucas County, in

[71] 36th An. Rep., Dept. Geol. Nat. Res. Ind., p. 558. See foot-note 70.
[72] Science, XXXIX, p. 844, 1914.
[73] Winchell, Geol. Ohio, II, p. 247.

marsh;[74] German Township, Montgomery County;[75] Ohio City, VanWert County, in alluvium on blue marl;[76] Deerfield Township, Ross County, in alluvium of a brook; Crawford County, in calcareous swamp diluvium; Sandusky, Erie County, in recent bog of muck; Massilon, Stark County, on Ohio canal, in quagmire less than two acres in extent, the tusks and bones resting on gravel and pebbles and covered by three feet of peat; Cincinnati, in valley drift; Preb'e County.

Klippart adds the following records:[77] Medina County, in marl pit; Cleveland, Cuyahoga County; McArthur, Hardin County; Woodstock, Champaign County; New Holland, Fayette County; between Madison and Pickaway counties.

A mammoth (*Elephas columbi*) has been reported from near Montville, Geauga County: "the remains were obtained from a small marsh, which had apparently been an open pond with a clay bottom, and which had been slowly filled from the growth of swamp vegetation; the remains being obtained from the clay at the bottom of the marsh."[78] Near Circleville, Pickaway County, the bones of both the mammoth and the mastodon have been found.[79]

Castoroides ohioensis is reported from Nashport, Muskingham County,[80] in valley drift and swamp mud; from near Greenville, Darke County, four feet below the surface in a swampy locality;[81] and from Preble County, with mastodon.[82]

The remains of *Platygonus compressus* have been discovered in great abundance in Cleveland.[83] They were found embedded in a calcareous clay, intermingled with calcareous sand, on the bank of the Olentangy River. Evidence of the presence of six small individuals was obtained at a depth of 8 feet below the surface, and six larger individuals were discovered 4 feet deeper. *Symbos cavifrons* has been reported from Trumbull County[84] and *Mylohyus nasutus* from Columbiana County.[84a]

[74] Geol. Ohio, I, p. 536.

[75] Geol. Surv. Ohio, 4th. Series, Bull. 16, p. 103.

[76] Whittlesey, Amer. Journ. Sci., V, p. 215, 1848. All that follow are from this reference Several records, especially those from valley drift, may belong to older formations.

[77] Cin. Quart. Journ. Sci., II, p. 153.

[78] Geol. Ohio, I, p. 526.

[79] Atwater, Amer. Journ. Sci., (i), II, pp. 245-246, 1820.

[80] Whittlesey, Amer. Journ. Sci., (ii), V, p. 215, 1848.

[81] Langdon, Journ. Cin. Soc. Nat. Hist., VI, pp. 238-239.

[82] Moore, *l.c.*, XIII, pp. 138-139.

[83] Klippart, Cin. Quart. Journ. Sci., II, pp. 1-6, 1875

[84] Leidy, Smith. Contr. Knowl., V, Art. 3, p. 16.

[84a] Hay, Iowa Geol. Surv., XXIII, p. 226.

VI. PENNSYLVANIA

Records of life from the glaciated portion of Pennsylvania are apparently rare. White,[85] many years ago, recorded a marl bed under 2-3 feet of peat in Erie County. The deposit is now one and a half miles from Conneaut Lake and it is thought at one time to have formed a part of this lake. The marl bed is over 22 feet thick and of wide extent, 60 acres being known in one place. The peat bog is 25 feet above the level of the present lake. A second bed of peat is reported under the marl bed. Eight species of mollusks were found in the marl.

Sphaerium striatinum	*Planorbis antrosus* (=*bicarinatus*)
Amnicola limosa	*Planorbis trivolvis*
Galba humilis [*modicella*]	*Planorbis campanulatus*
Physa heterostropha	*Planorbis parvus*

Van Rensaelaer[85a] records the mammoth from Beaverdam, Erie County. It was found near the border of a small rivulet about 600 feet above Lake Erie, and not far from the lake.

VII. NEW YORK

Records of the life of the ancient glacial lakes are exceedingly rare from this state. This paucity of knowledge is due doubtless to lack of observation rather than to absence of material. Mollusks (Unios) and wood have been reported from the Ridge Road bordering the south shore of Lake Ontario, which marks the shore of glacial Lake Iroquois (Algonquin stage).[86] No authentic lists of species from this beach have been seen. Eaton, many years ago, reported on the strata in the Erie canal, and mentioned the presence of organic remains in clay deposits.[87] *Picea canadensis* is mentioned and reference is made to "immense quantities of fresh-water shells." A list of the Mollusca is given, the identifications being made from Sowerby's Manual. Just what species were really represented it would be difficult to say with certainty.

Planorbis obtusa	*Bulla rivalis*
" *alba*	*Limnea longiscata*
" *paludosa*	" *minima*
" *annulata*	

It seems evident that much material of great value was collected from the Erie canal, and it is a pity that some American conchologist, like Say, could not have reported upon the species represented.

[85] Second Geol. Surv. Penn., 1879, QQQQ, pp. 40-41, 1881.
[85a] Amer. Journ. Sci., (i), XIV, pp. 31-33.
[86] Hall, Geol. of New York, part IV; Bell, Can. Geol., VI, p. 44.
[87] Amer. Journ. Sci., (i), XXI, pp. 138, 200; XII, pp. 17-20.

1. *Algonquin Stage (Lake Iroquois)*

The post-Pliocene shells of Goat Island, Niagara River, have been known for many years, but their relation to the ancient glacial lakes has but recently been recognized.[88] The deposits in which the shells are found were laid down during the Algonquin stage, about the time that Lake Iroquois was at its highest level. The Niagara River then connected a diminished Lake Erie with Lake Iroquois. The deposits consist for the most part of coarse, subangular fragments of rock, gravel, and some sand. Its depositional character shows that it was laid down in rapidly flowing water, where the current was too swift for stratification. The shells are usually found in cross-bedded strata, showing that they were placed in these deposits by the currents which moved the sand and gravel. Many of these deposits probably represent dead and loose shells which were picked up and moved along, but in a few instances they are found in situ (as at Prospect Park) indicating that they lived on the spot where they were buried.[89] Mollusks have been found at Goat Island, Prospect Park, Whirlpool, and Muddy Creek on the American side; and at Queen Victoria Park, Whirlpool, and Foster's Flats on the Canadian side. The comparative distribution is expressed in the table shown on page 149.

Similar material, consisting of large numbers of Unio shells in a soft and fragile condition, was recently found in the city of Niagara Falls, in an excavation in Falls Street, about 100 feet east of Prospect Street, at a depth of 9 to 10 feet.[90]

Of the species listed by Letson all but two are now living in western New York, in the Niagara River, or in lakes Erie and Ontario. *Fusconaja solida* is a Mississippi River species, not now living in the St. Lawrence drainage.[91] *Pleurobema cocicneum* appears to be referable to the form called *magnalacustris*, which is not uncommon in the Niagara River. *Amnicola letsoni* was at first described as an extinct species, but has since been found recently washed up on the shore of Lake Erie in Monroe County, Michigan, and from the drift of the Raisin River at Dundee, Michigan. *Goniobasis livescens niagarensis* differs from the variety as found elsewhere in the persistence of the peripheral keel in the adult stage.

Just what relation this fauna may bear to the smaller Lake Tonawanda,[92] which extended eastward up the valley of Tonawanda Creek for about fifty miles, is not known; there seems to be no reason why a lake fauna, such as the

[88] Letson, Bull. Buff. Soc. Nat. Sci., VII, pp. 238-252; Kindle and Taylor, Niagara Folio, No. 190, U. S. G. S., pp. 14, 19; Geol. Surv. Canada, Guide Book No. 4, p. 41.

[89] See Grabau, Bull. Buff. Soc. Nat. Sci., VII, pp. 61-68.

[90] Niagara Folio, p. 14.

[91] In Miss Letson's list this species is given as occuring in the Niagara River. The writer knows of no record from the St. Lawrence drainage.

[92] Kindle and Taylor, Niagara Folio, p. 19.

one in the Niagara gravels, should not have lived in this lake, which presented a favorable environment.

List of Species	Goat Island	Prospect Park	Queen Victoria Pk.	Muddy Creek	Whirlpool (American)	Whirlpool (Canadian)	Foster's Flats
Fusconaja solida		x					
Pleurobema coccineum (*magnalacustris?*)	x	x	x	x		x	x
Elliptio gibbosus	x	x	x	x		x	x
Alasmidonta marginata	x						
" *calceola*	x						
Eurynia ellipsiformis		x					
" *recta*	x						
Sphaerium striatinum	x	x	x		x		x
" *stamineum*	x	x				x	
" *torsum* (vide Sterki)	x						
Pisidium virginicum	x						
" *compressum*	x						
" *abditum*	x						
" *ultra-montanum*	x						
" *scutallatum*	x						
Campeloma decisum	x						x
Valvata tricarinata	x						x
" *sincera*	x						
Amnicola letsoni	x						
" *limosa*	x						x
" *emarginata* (=*obtusa*)	x						
Pomatiopsis lapidaria						x	x
Pleurocera subulare	x						
Goniobasis livescens	x	x	x	x	x	x	
" *livescens niagarensis*	x						
" *haldemani*	x						
Physa heterostropha	x					x	x
Planorbis antrosus (=*bicarinatus*)	x						x
" *parvus*	x						x
Pseudosuccinea columella	x						
Galba obrussa (=*desidiosa*)	x					x	x
" *catascopium*	x					x	x

Deposits referable to the Iroquois stage[93] (which is thot by Goldthwait to be older than the formation of Lake Algonquin[94]) occur near Ithaca, at the south end of Cayuga Lake. These deposits were discovered while making

[93] Tarr, Journ. Geol., XII, p. 79.

[94] Bull. Geol. Soc. Amer., XXI, pp. 227-241.

artesian well borings. The lacustrine deposits rest on the till and are from 200 to 300 feet in thickness. The sequence of strata is as follows:

Surface soil
Clay
Sandy clay, containing trees and mollusks
Gravel
Clay and stones
Clay
Till

The upper clay varies from 40 to 60 feet in thickness and contains fragments of mollusks and pieces of reeds and wood; logs were encountered in two cases at 38–39 and 33 feet; the sand and gravel varies from 20 to 70 feet and contain plant fragments, mollusks and many logs, several of good size; beneath the coarse material is a second layer of clay of considerable thickness, which overlies the true till. Prof. Penhallow identified the wood as follows: from south well, 30-35 feet in clay, *Pinus rigida*; from well No. 1, 50 feet, in gravel, *Larix americana*. Dr. Dall identified the molluscan genera as *Valvata*, *Planorbis*, *Amnicola*, *Pisidium*, and *Sphaerium*.

The evidence, according to Tarr, seems conclusive that these sands and gravels were either shallow-water, lake-margin deposits, or else stream-made land deposits, and that they were succeeded by lake conditions. To the writer they seem like lake-margin deposits, such as may be found on the southern shore of Cayuga Lake, where a great stretch of beach is covered with fragments of lake debris, consisting of mollusks, crayfish, fish, and hundreds of logs of all sizes. Like the Huron-Erie basin to the west, these deposits mark fluctuations in the level of the lake, and their interpretation would perhaps be as interesting as that already worked out at Chicago, and other places.

Six species of fresh water shells have been reported from New York City which are referable to late postglacial time. The deposit from which they came is thus described:[95] "The shells here mentioned were found at what is now 171st street and Morris Avenue, Borough of the Bronx, New York City. The swamp which is situated at this point lies in a long, narrow, anticlinal valley which has been eroded in limestone. When the street, now known as Morris Avenue, was filled in across the swamp, the peaty deposit, which had accumulated here, was forced up to heights of several feet on either side of it. This caused the peat to crack in all directions and revealed numerous pockets which were full of small shells." The species recognized are noted below.

Amnicola limosa	*Planorbis antrosus* (=*bicarinatus*)
Valvata tricarinata	" *parvus*
Physa heterostropha	*Pisidium variabile*

[95] Humphreys, Nautilus, XXIII, p. 10.

There are doubtless numerous small lakes in New York State which have marl deposits containing the remains of an ancient fauna. No records of such have come to the writer's notice, except one at West Chartton, Saratoga County, from which *Galba obrussa decampi* was obtained. The locality is said to be an extinct lake and the marl bed is under six feet of muck.[96] Near Schenectady, fossil leaves have been found, 10-12 feet below the surface of the flats or alluvial banks of the Mohawk River, in fine, black river mud.[97]

2. *Remains of Land Animals*

a. *The Mastodon*

That the mastodon once ranged over the entire state of New York is clearly indicated by a large number of its remains which have been found in widely separated localities. Clarke[98] has published a list of the known records, which is summarized below, arranged from the eastern to the western portion of the state.

Orange County. Montgomery, in marl beneath peat bog, 10-20 feet beneath the surface; Near Chester,[99] Newburg,[100] Scotchtown, Hamptonburg, Otisville, Monroe, Arden, Balmville, and Salisbury's Mills. The bones were found in sand, clay, or shell marl, beneath a bed of muck or peat.

Suffolk County. Between tides, four miles east of Riverhead; head of Beaseley's Pond near Jamaica, on gravel under about 4 feet of muck.[101]

Sullivan County. Between Red Bridge and Wurtsboro.

Ulster County. Ellenville.

Duchess County. Poughkeepsie, in marsh.

Greene County. Near Baltimore, Greenville, and Freehold.

Columbia County. Claverack.

Albany County. Coeymans.

Wayne County. Macedon.

Monroe County. Rochester, in hollow or watercourse; in Mount Hope cemetery; along Genesee Valley canal, where it crosses Sophia Street, 4 feet below the surface, in gravel covered by clay and loam, beneath a deposit of shell marl, and about 2 feet above the poilshed limestone; bank of Irondequoit Creek, two and one-half miles from Pittsford, 5 feet below the surface.

[96] H. B. McWilliams, In Smith. Inst. Coll.

[97] Tomlinson, Amer. Journ. Sci., (i), XXIII, p. 207.

[98] New York State Museum, Bull. 69, pp. 921-933.

[99] Hovey, in Ann. N. Y. Acad. Sci., XVIII, p. 147, says that this material was 6 feet below the surface in soil consisting of loose black mould, mingled apparently with comminuted fibres of sea weeds, etc., underneath a pale bluish clay.

[100] Stearns records the mollusk *Planorbis parvus*, with a mastodon from this locality (Nautilus, XIII, p. 101).

[101] Brevoort, Proc. A. A. A. Sci., XII, pp. 232-234, 1858.

Ontario County. Seneca, beneath marl and diatomaceous earth, about 3 feet from the surface.

Livingston County. Geneseo, mixed with marl and fresh water shells, a few feet below the surface; Nunda, Scottsburg, and Fowlerville.

Genesee County. Stafford, beneath muck, on clay and sand; Leroy, in bed of marl; Batavia.

Tompkins County. Near Ithaca, in deposit of modified drift.

Orleans County. Halley, in excavation for Erie canal.

Niagara County. Niagara Falls, in fine gravel and loam containing fresh water shells; found in digging a mill race on Goat Island, 12-13 feet below the surface.

Wyoming County. Pike; Attica, in unlaminated clay, 2-3 feet beneath surface, overlaid by clayey muck and loam.

Cattaraugus County. Hinsdale, with remains of deer (elk?), 16 feet below surface, in gravel and sand.

Chautauqua County. Jamestown, in muck, a little below present level of Lake Chautauqua, associated with bones of elk; Westfield, on pavement of heavy boulders, and under several feet of black clayey muck; at Levant, four miles east of Jamestown, leaves have been reported between layers of clay at a depth of 15 or 20 feet.[102] The vertical section at this locality is reported to be as follows:

Yellow sand	4 ft.	0 in.
Quicksand	0	4
Yellow clay	5	0
Blue clay	70	0
Hardpan	x	x
Total	79	4

The hardpan is probably referable to the old drift thot to be Kansan. (Why may it not be Illinoian?).

Staten Island. A mastodon's molar tooth, associated with twigs and cones of *Picea canadensis*, in a deposit two feet thick, 8 feet below the surface, was found in a Moravian cemetery at New Dorp. The locality is a swamp and is 1200 feet from the margin of the moraine. Whether this deposit is pre- or post-Wisconsin has not been stated.

Additional records are, Lisle, near Binghamton, Broome County;[103] Geneva, Ontario County;[104] Belvidere, Alleghany County.[105]

The remains of mastodons, as well as of other mammals, are usually found in clay or marl beneath a bed of muck or peat.

[102] Reis, Bull. N. Y. State Mus., III, No. 12, p. 103.
[103] Amer. Journ. Sci., (iii), X, p. 390, 1875.
[104] Hitchcock, Science, VI, p. 450, 1885.
[105] Amer. Geol., XXXIII, p. 60.

b. Other Vertebrates

Cervus canadensis.[106] Jamestown, Chautauqua County, in muck a little below present level of Lake Chautauqua, associated with the mastodon; Seneca, Ontario County, beneath marl and diatomaceous earth about 3 feet from the surface, associated with mastodon; Farmington, Ontario County,[107] in cedar swamp, in peat, 6 to 18 inches beneath the surface; New Hudson, Alleghany County (vide Hall).

New Hudson, Alleghany Co.[107a] Horns of elk and deer were found many years ago at New Hudson, four miles from Cuba, at the summit level of the old Genesee Valley canal, in a deposit of muck 12 feet beneath the surface, associated with pieces of wood gnawed by beavers.

Odocoileus virginianus. Cattaraugus, Green,[108] and Alleghany counties (Hall).

Platygonus compressus.[109] The remains of this animal were found by Prof. Henry A. Ward, many years ago, in a gravel bank excavated for a railroad near Rochester. This is the northernmost record for any member of this family. There seems to be no question concerning the occurrence of this extinct peccary during post-Wisconsin time.

Rangifer tarandus. The barren-ground caribou is reported from Sing Sing, New York, where antlers were found in the bed of an ancient lake (now a deep peat deposit) 6 feet below the surface.[110]

Castoroides ohioensis[111] has been reported from a swamp near Clyde, Wayne County, at an elevation of the Ridge Road (Iroquois Beach). The strata exhibit the following sections:

1. Muck and soil....................2 feet
2. Fine sand with occasional bands of clay, with alternating layers of sand, twigs, leaves and other fragments of vegetable matter....................2-3 feet
3. Much peaty soil, composed of fragments of wood, bark, leaves, and trunks of trees of large size. Skull of *Castoroides* in this stratum....................4 feet
4. Fine sand with shells of *Planorbis, Valvata, Cyclas,* etc....................2-3 feet
5. Ancient drift

Elephas columbi.[112] Two specimens of this elephant were found several years ago near Irondequoit River in Monroe County, ten miles east of Rochester. They were in a deposit of sand 4 feet below the surface, partly under the

[106] Clarke, *op. cit.*

[107] Hall, 6th An. Rep. State Geol. N. Y., 1886 (1887), p. 39.

[107a] Hall, Journ. Bost. Soc. Nat. Hist., V, p. 391, 1846.

[108] Hall, Geol. N. Y., part IV, 1843, pp. 364, 367.

[109] Leidy, Trans. Wagner Inst. Sci., II, pp. 41-50.

[110] Leidy, Proc. Phil. Acad., 1859, p. 194.

[111] Wyman, Proc. Bost. Soc. Nat. Hist., II, p. 138; Hall, Journ. Bost. Soc. Nat. Hist., V, p. 385-391.

[112] Miller, Bull. N. Y. State Mus., VI, No. 29, p. 373.

stump of a large forest tree.[113] The remains of a mammoth (species not recorded) were also found in a swamp near Crawford, Ulster County.[114]

Equus complicatus (=*major*). Miller[115] records a fossil horse from "Keenes Station, near Oswegatchie River oxbow in Jefferson County." Dr. Skelton[116] also cites a fossil horse (*Equus major*) from near Troy, Rensselaer County. No evidence is at hand to show that these records have been substantiated. Hay[117] has recently remarked that "no authentic specimens of fossil horse remains have been reported from any deposits overlying the latest sheet of drift, the Wisconsin," and the two records cited above are open to question. They may have been founded on the bones of the recent horse, that of Dr. Skelton being so considered by Hay.[118]

Bison bison was recorded many years ago[119] from the outlet of Chautauqua Lake, 10 feet below the surface in unbroken soil. Only a tooth was found, in a deposit of black muck.

Vertebrate remains have been found in postglacial deposits near Syracuse. These deposits are believed to be post-Iroquois and to have been made in a dimnishing Onondaga Lake following the Mohawk drainage of Lake Iroquois. They are 400 feet above sea level and 36 feet above the present Lake Onondaga. Mollusks were also found with the vertebrate remains but these have not been identified, as far as known.[119a] Four species of mammals are represented, as noted below:

Ursus americanus. Will and Baumer factory, north side of Ley Creek on east shore of Onondaga Lake.

Odocoileus virginianus. Same locality as above; Harbor Brook, near Avery Avenue (city line on west), Syracuse.

Bison bison. North side of Croton Street (near East Raynor Avenue) and 210 feet west of Renwick Avenue, Syracuse, about 10 feet below the surface at junction of muck and clay.

Elephas primigenius. East side of Limestone Creek near Manlius Station (now Minoa) on West Shore Railroad.

VIII. CONNECTICUT

The mastodon roamed about Connecticut during post-Wisconsin time. Stewart[120], long ago, reported this animal from two localities: in Farmington

113 Amer. Journ. Sci., (i), XXXII, pp. 377-379, 1837.
114 Thompson, Amer. Journ. Sci., (i), XXIII, p. 249.
115 Bull. N. Y. State Mus., VI, No. 29, p. 373.
116 Proc. Bost. Soc. Nat. Hist., VI, pp. 303-304.
117 Ind. Dept. Geol. Nat. Res., XXXVI, p. 586.
118 Science, N. S., XXX, p. 890, 1909.
119 Knight, Amer. Journ. Sci., (i), XXVII, pp. 166-168, 1835.
119a Smith, Bull. N. Y. State Museum, No. 171, pp. 64-72, 1914.
120 Amer. Journ. Sci., (i), XIV, p. 187.

canal near Cheshire, thirteen miles north of New Haven, in diluvial gravel; and at Sharon, in Litchfield County. In a later publication[121] a vertebra of a mastodon was reported from a canal in the town of Berlin, twelve miles southwest of Hartford. It was found in a tufaceous lacustrine formation containing the shells of *Planorbis*, *Lymnaea*, and *Sphaerium*.

IX. VERMONT

The remains of an elephant (species not indicated) were found in a cut in the Green Mountains, on the line of the Rutland and Burlington Railroad in 1850. The location was in the Township of Mount Holly, at an elevation of 1360 feet above sea level. The remains, consisting of a tooth, two tusks and several bones, were found in a muck bed, about 9 feet thick, resting on a gravel bed.[122] Fossil wood was also found near the elephant bones, 13 feet beneath the surface, covered by sand and gravel; the wood was cut by beaver's teeth. The deposit, 15 feet thick, rested partly on solid rock and partly on rounded masses of rock closely compacted together.[123]

X. MAINE

The northeastern part of Maine is studded with lakes, which are due to the last glacial invasion. Many of these lakes are, geologically, of very recent origin, dating from the Champlain submergence, and hence referable to Nipissing time. Many of these lakes have extensive marl deposits of great thickness, which contain an abundance of molluscan life. The deposits examined are all in Aroostook County, and their biotic contents have been made known by Mr. Olof O. Nylander. The mollusks, as listed by this gentleman, are indicated below. Those species not now living in these bodies of water are marked with an x.

Shells of Barren Brook bog, near Caribou,[124]

	Anodonta fragilis			*Pisidium walkeri mainense*	
	Sphaerium simile		x	*Valvata sincera?*	
	"	*rhomboideum*		*Physa heterostropha*	
x	*Musculium secure*		x	*Ancylus parallelus*	
x	*Pisidium adamsi*			*Planorbis trivolvis*	
	"	*compressum*	x	"	*campanulatus*
x	"	*contortum*	x	"	*antrosus*
x	"	*pauperculum*		"	*parvus*
	"	*rotundatum*		"	species (near *crista*)
x	"	*scutellatum?*		*Galba obrussa*	
	"	*variabile*		*Succinea obliqua*	
	"	*ventricosum*		*Vertigo* species	

121 Amer. Journ. Sci., (i), XXVII, pp. 165-166, 1835.
122 Thompson. Amer. Journ. Sci., (ii), IX, p. 256, 1850.
123 Proc. Bost. Soc. Nat. Hist., IV, pp. 33-34, 1851.
124 Nautilus, XIV, pp. 101-104.

Shells from Lovely Brook bog, near Fort Fairfield.

x	*Pisidium contortum*		*Physa heterostropha*
	" *ventricosum*	x	*Planorbis crista cristata*
	" *splendidulum*	x	" *hirsutus*
x	" *abditum*	x	" *parvus*
	" *variabile*		*Galba obrussa* (=*desidiosa*)

Shells from Little Mud Lake, Westmoreland.[125]

	Anodonta fragilis	x	*Pisidium triangulare*
x	*Sphaerium simile* (=*sulcatum*)	x	" *tenuissimum*
x	" *rhomboideum*		" *splendidulum*
x	*Musculium secure?*		" *splendidulum*, var.
	Pisidium variabile	x	" *abditum?*
x	" *compressum*	x	*Valvata sincera*, var.
x	" *adamsi affine*	x	*Ancylus parallelus*
	" *mainense*	x	*Planorbis campanulatus*
	" *ventricosum*	x	" *antrosus* (=*bicarinatus*)
x	" *costatum*		" *parvus*
	" *medianum minutum*	x	" *hirsutus*
x	" *contortum*	x	*Galba obrussa*

Mr. Nylander remarks that living mollusks are very rare in this lake, but that the fossil shells are very abundant. The water is evidently impregnated with mineral salts and the environment is becoming unfavorable for molluscan life.

XI. CANADA

Records of postglacial life have been definitely recorded from the territory north of the Great Lakes, notably in Ontario. The biota contained in these deposits is mainly lacustrine, altho a few land forms are represented, especially among the plants. Toward the east there is an admixture of both fluviatile and marine species, showing the close association of the lakes, rivers, and the sea during the Champlain substage. Only the lacustrine and fluviatile life will be exhaustively considered.

1. Lake Algonquin Stage

"No animal life has been found in the beach itself. But in a terrace adjacent to the Saugeen River (bridge east of Southampton), where there is an embayment of the Algonquin beach, there is a bed of fresh-water shells, discovered by Mr. Spillman. This is at an altitude of 90 feet above the lake, or 40 feet below the beach. This deposit may have been on the floor of the lake during the Algonquin episode, or it may belong to a lower water level. At the head of Georgian Bay, fresh water shells have been found up to 78 feet."[126] No list of the species from these deposits has been observed.

[125] Nautilus, XXII, pp. 105-106. The deposit is said to be many feet in thickness.

[126] Spencer, Amer. Journ. Sci., (iii), XLI, p. 16, 1891.

Dr. Stearns[127] lists the following species from the "fossiliferous sands overlying the clays of Essex County, Ontario," associated with mastodon remains. The deposits are probably referable to the Algonquin stage tho they might belong to an earlier period.

Valvata sincera	*Planorbis parvus*
" *tricarinata*	" *campanulatus*
Physa heterostropha	*Galba humilis modicella*

Near Collingwood, Simcoe Distirct, on the Nottawassaga River, several species of mollusks occur in sedimentory deposits,[128] which are probably referable to the Algonquin stage, altho the section near Collingwood seems rather low for this stage, but it is above the level of the Nipissing stage (632 feet).[129] The section near Nottawa seems referable to the Algonquin stage. Fossils are reported as follows:

North side of Pretty River, Nottawa, in deposit from 3 to 4½ feet beneath the surface.

Polygyra albolabris	*Pyramidula alternata*
" *tridentata*	*Omphalina fuliginosa*
" *sayii* (=*sayana*)	

Deposit near Collingwood, from surface to depth of three feet; height of section 78 feet above the lake (659. 5 A.T.).

Planorbis trivolvis	*Polygyra albolabris*
Goniobasis conica[130]	" *tridentata*
" *livescens*	*Omphalina fuliginosa*

At the town of Angus, in Simcoe district, beds of lacustrine shells have been observed which are probably referable to the Algonquin stage.[131] The town of Colwell, not far distant, is on the Algonquin beach, which reaches a height of 774 feet,[132] and Angus is doubtless also situated on this beach. The species recorded below are listed by Bell[133] and Coleman.[134]

Elliptio complanatus (very abundant)	*Planorbis antrosus* (=*bicarinatus*)
Lampsilis luteola	" *campanulatus*
Sphaerium simile	" *trivolvis*
" *rhomboideum*	" *deflectus*
Pisidium dubium (=*virginicum*)	" *parvus*
" *noveboracense*	*Physa ancillaria*
Amnicola limosa	*Galba obrussa* (=*desidiosa*)
" *limosa porata*	" *palustris*

[127] Stearns, Nautilus, XIII, pp. 100-101.

[128] Geol. Can., p. 966; Dawson, Can. Nat., VI, pp. 49-50.

[129] See Goldthwait, Geol. Surv. Can., Mem. No. 10, p. 24.

[130] It is difficult to surmise just what this species may have been. *Conica* is a synonym of *Pleurocera canaliculatum* Say, a species not found in the northern part of the country.

[131] Hunter (Can. Geol. Surv., Rep. 1902, p. 290 A) refers these shells to the Nipissing stage.

[132] Goldthwait, *op. cit.*, page 24.

[133] Geol. Can., page 966.

[134] Trans. Can. Inst., VI, p. 40.

Valvata tricarinata	*Galba elodes*
" *sincera*	*Succinea avara*
" *piscinalis*[135]	*Polygyra monodon*
Goniobasis livescens	

Chapman[136] lists many of these species and remarks that the shells may be traced over four miles south of the station and a mile or more in other directions. They lie in fine sand at depths of 1 to 16 or 18 feet and are underlaid by gravel, which is in some places obliquely laminated. The naiads were very abundant, of large size and well preserved, "a cart load might be collected from some cuttings in an hour." From this description it would appear that the deposit was very similar to the Toleston beds of Wilmette Bay, Chicago, described in Chapter III.

In 1898, fossil Unios, fish bones and pieces of wood and bone were found in a well on the Agnew farm, near Essa, on the Nottawasaga River.[137] At Ennskillen, Ontario (opposite Detroit) several mollusks have been reported from gravel deposits apparently referable to Lake Algonquin. Three species are recorded.[138]

Unio circulus = *Obovaria circulus*
" *gibbosus* = *Elliptio gibbosus*
Cyclas (many) = *Sphaerium*

2. *Lake Iroquois Stage*

The records of life from this ancient beach are not numerous. At Hamilton,[139] the scapula of a deer is said to have been found in beach sand and gravel. On Burlington Heights, near Hamilton, a number of mammals were found in fine sand, about 38 feet below the summit of the ridge and 70 feet above the surface of Burlington Bay. The upper 30 feet consisted of stratified gravel, composed of small pebbles of limestone, cemented to such an extent that the deposit had to be blasted to remove it. Beneath this was a deposit of coarse sand, about 10 feet in thickness, in which the bones were found. The specimens were discovered during the construction of the Desjardins canal. Four species were observed.

Elephas jacksoni = *Elephas columbi* (tusk and lower jaw)
Mastodon americanus = *Mammut americanum* (tusk and vertebra)
Cervus canadensis (horns)
Castor fiber = *Castor canadensis* (jaw).

[135] This species may be the same as *Valvata obtusa* Drap., which is abundant on the southern shore of Lake Ontario in the vicinity of Irondequoit Bay and Charlotte. *Piscinalis* has recently been authentically reported from American waters by Latchford, Nautilus, XXVIII, p. 10.

[136] Canadian Journ., N. S., VI, pp. 497-498, 1861.

[137] Hunter, *op. cit.*, p. 291A.

[138] Bell, Geol. Canada, p. 956.

[139] See Trans. Can. Inst., VI, p. 29; Can. Nat., N. S., VII, p. 470; VIII, pages 135-147; X, p. 308.

In Hamilton, just west of the Catholic cemetery, bordering the Dundas marsh, a bed of shell marl occurs, which is about 15 feet in thickness. As the mollusks are all land species they may belong to a later period. Four species are listed.[140]

Polygyra albolabris	*Pyramidula alternata*
" *tridentata*	*Succinea obliqua*

Near Toronto several localities exhibit good exposures of the Iroquois beach.[141] From street cuttings in the sandy plain east of the Don River, four mollusks were obtained.

Elliptio complanatus	*Galba palustris?*
Planorbis campanulatus (in error *complanatus*)	*Succinea avara*

From Reservoir Park a number of specimens, more or less perfect, were secured.

Unios, several species, worn	*Pleurocera*, several species
Sphaerium, "	*Campeloma decisum*

From the Carlton sand and gravel pit, 12 to 20 feet below the surface, in a gravel and on a clay deposit at the base of the gravel, the cast horns of a barren ground caribou were found. Other specimens have been found in the vicinity. From a gravel deposit at York a mammoth tooth was taken.

Near the Don River above Taylor's first paper mill a well was drilled on the hillside, 35 feet below the level of the Iroquois beach. The drill penetrated 38 feet of sand and gravel, often cemented by carbonate of lime; shells were encountered 70 feet below the level of the Iroquois beach. The sand deposit rests upon the surface of weathered peaty clay, which is thot to be interglacial. This weathered zone may represent a low-water stage and the mollusks may have been buried during the rise of the water. The mollusks found belong to the genera *Unio*, *Sphaerium* and *Pleurocera*.

Ami[142] enumerates the following species from the gravel pits of west Toronto, referring them to the Lake Warren episode. Coleman refers all post-Glacial deposits to the Iroquois Stage.[143]

Lampsilis luteola	*Goniobasis livescens*
Sphaerium rhomboideum	*Physa ancillaria*
Pisidium abditum	*Planorbis campanulatus*
" *noveboracense*	" *bicarinatus* (=*antrosus*)
Valvata sincera	" *deflectus*
" *tricarinata*	" *parvus*

[140] See Coleman and Spencer, Trans. Can. Inst., VI, p. 29; Can. Nat., N. S., VII, p. 470; X, p. 308.

[141] Coleman, *op. cit.*, pp. 37-39.

[142] Trans. Roy. Soc. Can., (ii), VI, part iv, p. 153.

[143] Bull. Geol. Soc. Amer., XIV, pp. 347-368.

Amnicola limosa	*Galba elodes*
" *limosa porata*	*Succinea avara*
	Polygyra monodon

The tusk of an elephant eleven inches long and three inches in diameter was found in Adair's pit.

At Niagara Falls, on the Canadian side, fresh-water shells occur in many places. In a deposit of sand and gravel lying between the Clifton House and the old toll-gate below, the species indicated below were found:[144]

**Elliptio complanatus*	*Goniobasis acuta* (=*haldemani*)
" *gibbosus*	" **conica*[130]
Obovaria ellipsis	" *livescens*
Eurynia recta	*Physa heterostropha*
Alasmidonta marginata	*Planorbis bicarinatus* (=*antrosus*)
**Sphaerium simile*	**Galba caperata*
**Pisidium dubium* (=*virginicum*)	**Lymnaea stagnalis appressa*
Campeloma decisum	**Polygyra albolabris*
**Amnicola limosa porata*	

This deposit is between the ancient bank of the river and the edge of the present gorge and is clearly referable to the Iroquois stage.

Deposits of gravel in Queen Victoria Park contain several species of mollusks which are listed by Coleman[145] and Kindle and Taylor;[146] the latter authors refer the deposits to the recent stage of the Niagara River rather than to the Lake Iroquois stage. Some of the deposits may, however, be older, as remarked by Kindle and Taylor, and the gravels containing the shells may have been laid down in a late stage of Lake Iroquois. The list includes four species not in Letson's Goat Island catalog; one of these (*Unio clavus*) may be a case of misidentification, this usually being a species of more southern distribution. It is, therefore, eliminated from the list below.

Fusconaja solida	*Sphaerium striatinum*
Pleurobema coccineum	" *solidulum*
Elliptio gibbosus	*Pleurocera subulare*
Eurynia recta	*Goniobasis livescens*
Lampsilis luteola	*Physa heterostropha*
" *occidens* (=*ventricosa*)	*Galba desidiosa* (=*obrussa*)

The presence of two feet of weathered till beneath the Iroquois gravels suggests, says Coleman, a low water stage between Lake Warren and Lake Iroquois. This low water stage must have been of considerable duration, be-

[144] Bell, Can. Nat., VI, page 46. These names have not been verified. Those marked with an * are not included in Miss Letson's list. Bell's specimens are not now to be found in the Geological museum at Ottawa. What the species really was that is recorded as *Unio complanatus* it is impossible to conjecture, as *Unio gibbosus* is also listed. As the later writers have failed to find this naiad in these deposits it must be looked upon as an erroneous identification until the original specimens are found, if they are still in existence.

[145] 12th Inter. Geol. Cong., Toronto, Canada, Guide Book No. 4, p. 42, 1913.

[146] Niagara Folio, p. 14, 1913.

cause tamarack and spruce had time to grow and thrive at Hamilton. In the Don Valley, at Toronto, there are valleys of erosion in the interglacial till which also attest an extensive stage of low water. Coleman further suggests that the erosion in the Don Valley may have been pre-Warren. It might possibly represent the Lake Arkona stage.

3. *Nipissing Great Lake Stage*

The City of Owen Sound is built upon both the Algonquin and Nipissing beaches, the former at 748 and the latter at an elevation of 625, 627, and 633 feet.[147] Many years ago, Robert Bell[148] listed several species of mollusks which were collected from the bank of the Sydenham River, 9 feet above the lake. Mollusks were obtained at higher elevations also. As the datum for Lake Huron is 581.5 feet A.T., the deposit from which the shells were secured was at an elevation 600.5 feet. This is below the crest of the Nipissing beach (625 to 653 feet) and the specimens are therefore referable to the Nipissing stage. The following species are listed by Bell.[149]

Sphaerium simile
Campeloma decisum
Goniobasis acuta (=*haldemani*)
" *conica*[150]
" *livescens*
Amnicola limosa porata
Valvata sincera
" *tricarinata*
Planorbis bicarinatus (=*antrosus*)
" *campanulatus*
" *parvus*
Galba umbrosa (=*elodes*)
Pyramidula alternata

About a mile south from the river, a lacustrine deposit of sand containing shells was found, upwards of 30 feet above the lake (Bell, l.c., p. 51). These might be referable to a period between the Algonquin and Nipissing stages.

In the area south of the Ottawa River, west of the city of Ottawa, a number of marl deposits occur. These are in lakes of greater or less size and the deposits vary in thickness from 4 to 12 feet.[151] The best localities are noted below: Mink Lake, near Eganville; chain of lakes in Ross Township, extending southeast from Muskrat Lake; lake bottom on lots 9 and 10, Westmeath Township; all in Renfrew County. These lake and pond beds represent depressions in the bottom of the outlet of the Nipissing Great Lakes and the fauna contained in these deposits may be referred to this stage, tho a portion of them may have been laid down at a later period, particularly the surface layers. Seven species of mollusks are recorded by Ami.[152]

Elliptio complanatus
Anodonta fluviatilis
Physa heterostropha
Planorbis campanulatus

[147] Goldthwait, Mem. Can. Geol. Surv., X, p. 23.

[148] Can. Nat., VI, p. 50.

[149] It is impossible to verify these records, and they are listed substantially as originally recorded by Bell in Can. Nat., VI, p. 50 and Geol. Can. 1863, p. 967.

[150] Foot-note number 130.

[151] Ells, Rep. Geol. Surv. Can., No. 977, p. 46.

[152] Rep. Geol. Surv. Can., 1899, pp. 53, 71.

Sphaerium orbicularis (=*partumeium*)	*Planorbis bicarinatus* (=*antrosus*)
Campeloma decisum	

Heron[153] lists sixteen species from the vicinity of Ottawa,as noted below.

Valvata tricarinata	*Ancylus* species
Amnicola limosa porata	*Galba desidiosa* (=*obrussa*)
Planorbis campanulatus	*Sphaerium rhomboideum*
" *parvus*	" *sulcatum* (=*simile*)
" *exacutus* (=*exacuous*)	*Pisidium ventricosum?*
" *bicarinatus* (=*antrosus*)	" species
Physa heterostropha	*Elliptio complanatus?*
" *ancillaria*	

On the shore of Hemlock Lake, near Rockcliffe Park, a bed of shell marl occurs, which is said to be five feet in thickness. This is probably also referable to the Nipissing stage. The following molluscan and other species have been identified from this marl:[154]

The elevation of the marl beds is 18-20 feet above the present level of the lake, which is 15 feet above the Ottawa River. The marl fauna is said to consist of smaller individuals of species now living in the lake, due either to adverse physical conditions or to a boreal climate.[154a]

Pisidium abditum	*Lymnaea stagnalis appressa*
Valvata tricarinata	*Euconulus fulvus*
Amnicola limosa porata	*Vitrea indentata*
Physa heterostropha	*Zonitoides arborea*
Planorbis bicarinatus (=*antrosus*)	*Pyramidula alternata*
" *campanulatus*	*Polygyra albolabris*
" *parvus*	" *albolabris dentifera*
Galba galbana	" *sayii* (=*sayana*)
" *desidiosa* (=*obrussa*)	*Cypris* species[154a]

Near Cobalt, Ontario, heavy beds of marl occur which contain a large and varied molluscan fauna. These are listed by Walker as indicated below:[155]

Sphaerium simile	*Pisidium vesiculare*
" *striatinum*	*Valvata tricarinata*
Musculium secure	*Physa heterostropha*
Pisidium kirklandi	*Ancylus parallelus*
" *contortum*	*Planorbis campanulatus*
" *rotundatum*	" *antrosus striatus*
" *noveboracense*	" *exacuous*
" *mainense*	" *parvus*
" *medianum*	" *deflectus*
" *pauperculum*	" *hirsutus*

[153] Trans. Ottawa Field Nat. Club, I, p. 40, 1880.
[154] Ami, Rep. Geol. Surv. Can., 1899, p. 56, G.
[154a] Whittaker, Ottawa Nat., XXXII, pp. 14-18, 1918.
[155] Ottawa Nat. XXI, p. 180.

Pisidium tenuissimum	*Pyramidula cronkhitei anthonyi*
" *scutellatum*	*Zonitoides arborea*

Of the Pisidia Dr. Sterki says, "it is interesting to note that most of the species are represented by small and, in some cases, specifically northern forms."

From the marls of the drained lakes on the island of Montreal 8 species of fresh-water mollusks are recorded.[155a]

Sphaerium portumlium (=*Musculium partumeium*)	*Lymnaea stagnalis* (possibly *appressa*)
Planorbis campanulatus	*Physa heterostropha*
Planorbis parvus	*Valvata tricarinata*
Planorbis bicarinatus (=*antrosus*)	*Amnicola porata*

4. *Vertebrate Remains*

The mammoth and mastodon roamed over eastern Canada during post-Wisconsin time and the remains of these animals have been found in many places. Panton[156] mentions the following localities:

Mastodon: Highgate, Ontario, in a marl bed.

Mammoth: Shelburne, Ontario, in a marl bed.

Other Proboscidia have been noted at St. Catharines, Dunnville, Kimball, Goat Island, and Niagara Falls. Bell[157] records the mammoth from a swamp on lot 9, Range VII, of the Township of Amaranth, Wellington County, fifty miles northwest of Toronto; and the mastodon from banks of sand and gravel in the valleys of Middle and Braddock rivers, in the central part of Cape Breton Island, Nova Scotia. Chapman[158] records the mastodon from Morpeth, Kent Co., Ontario, in drift on a limestone ridge, 7 feet beneath the surface. The recently described *Cervalces borealis* is reported from near Brantford, Ontario, in post-Wisconsin deposits .[158a]

Both the elephant (*Elephas columbi*) and the mastodon reached a high latitude in Canada either during the Nipissing episode or later. Bell reports the remains of the elephant from the east side of Hudson Bay on Long Island; from Edmonton, Alberta, in the bank of the North Saskatchewan River in superficial deposits; and in the Valley of Shell River at its junction with its east branch. The mastodon has been recorded from the bed of Moose River, at the first bend below the junction of the Missinaibi and the Mattagami to form the trunk stream. This is forty-six miles below Moose factory. Lignite occurs in the bank of the river, and the deposit is thot possibly to be interglacial. The elephant, mastodon, bison, and other vertebrates have been recorded from

[155a] Stansfield, Geol. Surv. Canada, Memoir 73, p. 68, 1915.
[156] Rep. Brit. As. Ad. Aci., 61st Meeting, 1891, pp. 654-655, 1892.
[157] Bull. Geol. Soc. Amer., IX, pp. 389-390.
[158] Can. Journ. Ind. Sci. Art, N. S., III, pp. 56-57.
[158a] Hay, Iowa, Geol. Surv., XXIII, p. 263.

Alaska, but these may have lived in this region during the expansion of the ice, portions of this region not having been covered by the continental glacier.

5. *Glacial Lake Agassiz*

As the Iowa and Dakota ice lobes retreated northward (Plate XLVI) a ponding of the waters took place in North Dakota, Minnesota, and Canada, which at first found an outlet thru the Minnesota River and Lake Traverse into the Mississippi River. This outlet is called the Lake Traverse outlet. This lake grew to the northward until it became the largest of all the Glacial lakes, later finding an outlet to the north, and finally, after the ice had completely withdrawn from the Hudson Bay region, becoming extinct. Lake Winnipeg is in a sense a successor of this huge lake. Several important beaches mark the limits of the different stages of Lake Agassiz, in some of which evidences of life have been found. This lake is believed to be correlative with the Warren and Algonquin stages of the Great Lakes.

The biota which had been driven south by the Wisconsin invasion again advanced into the englaciated territory as soon as conditions were favorable. The aquatic life emigrated into the Lake Agassiz basin in much the same manner as did the biota which took possession of Lake Michigan thru the Chicago outlet, but at a later period. The route was via the Lake Traverse outlet. Life has not been found as abundantly in the Lake Agassiz deposits as in those of the Lake Michigan basin, probably because exposures in protected spots have not been observed. The Gladstone beach, one-half mile northeast of Gladstone, Manitoba, has yielded several species of mollusks. This beach is 875 feet above the sea and 165 feet above Lake Winnipeg. Four species are recorded.[159]

Lampsilis luteola	*Sphaerium sulcatum* (=*simile*)
Sphaerium striatinum	*Planorbis parvus*

From stratified clay deposits of Rainy River, Ontario, Coleman reports:

Eurynia recta?	*Sphaerium*, 2 species

Fresh water shells have been reported from old lake deposits north of Lake Superior, by Coleman, Bell, and others. Six miles southwest of Campbell Minnesota, in the Campbell beach, which is here 985 feet above the sea, Upham[160] found *Unio* (*Obovaria*) *ellipsis*. In the reports of the Geological and Natural History Survey of Minnesota, especially in the Final Reports, reference is made to a number of locations where evidences of life have been found in the bed or outlet of this ancient lake. These are briefly noted below:

[159] Upham, Rep. Prog., Can. Geol. Surv., p. 49 E, 1900; Lake Agassiz, p. 237; Coleman, Trans. Can. Inst., VI, p. 40.

[160] Amer. Geol., VII, pp. 222-223.

a. *Bed of Lake Agassiz*

Beltrami County, in bed of Rainy River at confluence of Pine River and at mouth of Beaudette River.[161]

Sphaerium sulcatum (=*simile*)	*Planorbis bicarinatus* (=*antrosus*)
" *striatinum*?	*Galba obrussa*

A specimen of the buffalo, *Bison americanus* (=*bison*) was found in the first rapid on Pine River, in a ridge of gravel mixed with clay.[161] In Clay County,[162] at Georgetown, mussel shells are said to have been found in a well 10-12 feet below the surface, in clay. It is unfortunate that these organic remains were not preserved and identified. In the Glyndon well,[162] strata containing organic matter were passed thru, as indicated below:

Soil	1	foot
Yellow quicksand	12	feet
Blue quicksand, with sheets of turf and vegetable deposits	3½	"
Blue clay and drift wood	2	"
Blue clay	2½	"

Upham (page 664) believes that this material was deposited from rivers in their stages of flood, after Lake Agassiz was drained into Hudson Bay. In Becker County,[163] a bed of shell marl occurs in the banks of Buffalo River in Sect. 28, T. 41, R. 41, seven miles south of White Earth Agency, the stream in the valley being 30-40 feet below the surrounding country. The banks twenty rods southeast from the bridge exhibit in section,

Soil	2 feet
White shelly marl	1 "
Alluvial sand and gravel to level of water	6 "
Total	9 feet

In Wilkin County,[164] in the town of McCauleyville, in the cellars dug in alluvial clay, many large bivalve shells and small gastropods were found 5 feet below the surface and 20 feet above Red River. In this vicinity shells like those of sloughs are often noticed in ploughing or digging, to a depth of six feet. Penhallow[165] records *Larix churchbridgensis* from southern Manitoba, in postglacial deposits.

[161] Grant, Geol. Nat. Hist. Surv. Min., Final Rep., IV, p. 189.
[162] *Op. cit.*, II, pp. 668, 669.
[163] *Op. cit.*, p. 653.
[164] *Op. cit.*, p. 529.
[165] Rep. Can. Geol. Surv., 1890-1891, p. 143 E, 1892.

b. *Outlet of Lake Agassiz*

In Lac qui Parle, NE ¼ Sect. 30, a well gave the section indicated below. The shells were not identified.[166]

Soil	2 feet
Clayey silt, containing numerous bivalve shells	8 "
Yellow till	7 "
Sand	½ foot
Blue till interstratified with sand	14 feet
Total	31½ feet

In Renville County,[167] on the east bank of Hawk Creek, a terrace of gravel and sand occurs, fifteen feet above the stream, which contains a calcareous bed about 2 feet thick, 6 or 8 feet above the water. Eight species of mollusks have been identified from this bed.

Unio, species	*Goniobasis livescens?*
Anodonta, species	*Valvata tricarinata*
Sphaerium striatinum	*Amnicola limosa*
Campeloma, species	*Planorbis parvus*

The shells are believed to have lived during the time of the outlet of Lake Agassiz. In Nicollet County,[168] at Ashawa, gastropod shells occur 5 feet below the surface in the section noted below. Land shells occurred both above and below the shell bed.

Surface, sandy	3-4 feet
Clayey silt	10 "

In the city of Minneapolis, at the corner of Washington Avenue and 15th. Avenue, *Castoroides ohioensis* was found[169] associated with fragments of Unios. The deposit was at a depth of 8 feet, overlaid by sandy loam and underlaid by brick clay. The location is about twenty feet above the present surface of the Mississippi River.

c. *Vertebrate Animals*

Proboscidian and other vertebrate animals have been found in and near the area of the old Lake Agassiz basin.[170] *Elephas* (listed as *primigenius*) is recorded from the following places in Minnesota:

Fair Haven, Stearns County, in marsh.
Wabasha, in gravel terrace of Mississippi River.
Lake City, near Stockton, on shore of Lake Pepin.

[166] Min. Geol. Nat. Hist. Surv., Final Rep., I, p. 630.
[167] *Op. cit.*, II, p. 201.
[168] *Op. cit.*, II, p. 178.
[169] Winchell, 8th. An. Rep. Min. Geol. Nat. Hist. Surv., 1879, pp. 181-183.
[170] Winchell, Bull. Min. Acad. Sci., IV, pp. 414-422.

In North Dakota, near Repon, Cass County, *Elephas* remains have been found in the Herman beach of Lake Agassiz, about one foot below the surface of the Wisconsin till sheet, and below the gravel of the beach.[171]

The mastodon was rare in Minnesota, judging by the absence of authentic records. A tusk eight and a half feet in length is reported from Northfield, Fairebault County, in drift ten feet below the surface.[172] A jaw bone is also reported from a gravel bank at Albert Lea, Freeborn County.[173] Proboscidian remains, either mastodon or elephant, have been reported from various places in Minnesota as noted below:[174]

Minnesota City, Winona Co., and Stillwater Washington Co., in terrace gravel of flood plain stage of Wisconsin time. Minneapolis, Hennepin County. Minnetonka, Hennepin County. Mankato, Blue Earth County.

Bison latifrons is recorded by Winchell[175] from Mora, Kanabec County, in clay of ditch, several feet below the surface. *Ovibos cavifrons*[176] is also reported by Winchell from between Wabasha and Thielman, in the gravel terrace of the valley, ten feet below the surface. Winchell places the deposit as probably in the Wisconsin terrace epoch or possibly in Iowan loess. As the deposit may be of Peorian age, it is also recorded in Chapter X, page 351.

"In the vicinity of the Lake of the Woods, horizontally bedded, finely laminated, yellowish-gray, silty clay occurs, which in places occupies the surface up to a height of 15 or 20 feet above the lake and unconformably overlies the yellow till or bluish laminated stony clay. Fresh water shells are numerous in the deposit.

"The presence of the shells in these deposits and in many of the beach ridges in this district up to an altitude of at least 140 feet above the lake suggests a correlation in time and that different conditions existed at the time of the deposition of the lacustrine clays than when the glacio-lacustrine deposits were laid down."[176a]

IV. Records of Life Outside the Area and Influence of the Great Glacial Lakes

The remains of postglacial biota have been found in places remote from the large lakes formed by the retreating ice. These remains are usually found in marl beds of small lakes, in river terraces and in ancient soil formations. Only a few records of such are available. These are listed by states.

[171] Upham, Glacial Lake Agassiz, p. 322.
[172] Geol. Nat. Hist. Surv. Min., Final Rep., I, p. 670.
[173] *Op. cit.*, p. 386.
[174] Bull. Min. Acad. Sci., IV, pp. 414-422.
[175] Bull. Min. Acad. Sci., IV, No. 3, pp. 414-422.
[176] *Op. cit.*, page 420.
[176a] Johnston, Summary Report, Can. Geol. Surv., 1913, pp. 173, 174.

A. NEW JERSEY

1. *Fresh Water Formations*

Northern New Jersey is studded with glacial lakes left after the retreat of the Wisconsin ice sheet. Many of these doubtless contain interesting deposits of postglacial life, but only one, White Pond, near Marksboro, Warren County, has been critically examined. Leidy[177] and Baker[178] have listed the species of fossil mollusks found in this small lake. These are indicated below. Of the fourteen species listed, *Amnicola* and *Valvata* make up 95 per cent of the material, clearly showing their relative abundance. *Galba galbana* is now of more northern distribution and *Amnicola galbana* is extinct.

Pisidium compressum
Amnicola limosa
" *galbana*
Valvata tricarinata confusa
" *tricarinata infracarinata*
Physa ancillaria
Aplexa hypnorum
Planorbis antrosus
Planorbis antrosus striatus
" *campanulatus*
" *deflectus*
" *exacuous*
Galba galbana
" *humilis modicella*
Succinea retusa

2. *Land Formations*

The mastodon and mammoth have been found in a number of localities in New Jersey, within the glaciated portion in the northwestern part of the state. Nearly a hundred years ago,[179] the skeleton of a mastodon was found three miles southwest of Long Branch, in the County of Monmouth. It was in a marsh which presented the following section:

1. Black earth containing Mastodon	8 feet
2. Silicious sand with rolled pebbles	8 " (usually)
Marl formation	10 to 30 feet

Lockwood[180] reports three additional records from Monmouth County; (1), Fifteen miles south of Long Branch, in swamp; (2), at sea off Long Branch and in a peat meadow about two miles west of Freehold, resting on hardpan; beneath peat. Leidy[181] also reported the mastodon from Warren County, and Maxwell[182] recorded the same species from near Hackettstown, Warren County. Stewart[183] has reported the mammoth from the Morris canal, near Schooley's Mountain, Morris County, three feet beneath the surface.

[177] Proc. Phil. Acad., II, pp. 279-281, 1845.
[178] Nautilus, XVII, pp. 38-39, 1903.
[179] Ann. Lyc. Nat. Hist., I, pp. 143-147, 1824.
[180] Proc. A. A. A. S., XXXI, pp. 365-366, 1882.
[181] Proc. Phil. Acad., 1870, p. 96.
[182] Proc. Amer. Phil. Soc., IV, pp. 118-121, 127, 1845.
[183] Amer. Journ. Sci., (i), XIV, p. 188.

The reindeer (*Rangifer tarandus*) has been found near Vincentown, Burlington County, in green sand marl, at a depth of four feet.[184] The fine specimen of *Cervalces americanus* (=*scotti*) described by Scott,[185] and recorded from a marl deposit under a bog at Mount Hermon, Warren County, six miles from Delaware station, on the D.L. & W. R.R., is also to be included in the postglacial fauna.

3. *Plant Remains*

Berry[186] has recorded a few species of plants from near Long Branch, Monmouth County, in peat. The following species are listed:

Species	Present range
Juniperus? virginianus? (seed)	Canada and New England to Florida
Hicoria glabra? (seed)	" " " " "
Vitis aestivalis (seed)	Not now ranging N. of S. Maryland
" *pseudorotundifolia* (seed)	" " " " "
Quercus phellos	" " " " "
Taxodium distichum (cone scales)	" " " " "
Pinus taeda (cones and scales)	Northern limit Cape May Co., N. J.
Zizyhus species	Mainly tropical and not now found in northern coastal plain.

Berry comments as follows on this collection of plants: "In Europe the last glacial retreat was succeeded by a period during which the climate was considerably warmer than it is at the present time as shown by the extension of various members of the existing flora for many miles to the northward of their present range." The plants from the Long Branch locality are, perhaps, subject to the same interpretation.

B. MASSACHUSSETTS

Following the retreat of the Wisconsin ice sheet from the west-central portion of the state, several lakes of good size were formed in the Connecticut Valley. These lakes were three in number, were confluent, and have been christened Hadley, Springfield, and Montague. In Lake Hadley, great delta deposits were formed at the mouths of such rivers as the Manham and the Westfield, and these were later covered with alternate layers of fine clay and sand in which certain plants were entombed. Of these deposits Emerson writes as follows:[187]

"With the rise of each spring flood a new layer of sand and gravel was carried across the delta flat, and the finest sand was spread in a thin layer far out across the lake bottom, dwindling in size of grain and thickness. In the

[184] Leidy, Proc. Phil. Acad., 1858, p. 179.

[185] Amer. Nat., XIX, p. 495, 1895.

[186] Torreya, X, pp. 261-267, 1910.

[187] Holyoke Folio, U. S. G. S., No. 50 p. 7; Mon. XXIX, U.S.G.S., pp. 739-740.

winter the stagnating waters clarified themselves, and the layer of clay resulted. It is on the surface of these exceedingly thin sand layers that fossil leaves occur in the clays exposed along the river bank below Hadley, in the clay pits near the asylum in Northampton, at the Central Railroad station, and at the clay pits near Kellogg's plane factory in Amherst."

The plants observed in these deposits have been identified as:

Viola palustris	*Arctostaphylos alpina*
Vaccinium oxycoccus	" *uva-ursi*
" *uliginosum*	*Salix cutleri(=uva-ursi)*
Oxygia digyna	*Lycopodium selago*
Rhododendron lapponicum	

These vegetable remains represent species which extend well into the boreal or Arctic zone of today, and they apparently lived in post-Wisconsin time not many miles south of the melting glacier.

Alluvial terraces were built up following the draining of the Glacial lakes and on these the waters of the rivers spread layers of fine sediment, in which some of the biota of the region became buried. North of Hadley, near the mouth of the Freshman River, several sections occur which reveal the old bed of this river. In these deposits the remains of both plants and animals have been observed. Ten plants and five insects are represented, as noted below:

Plants[188]

Ranunculus aquatilis	*Carya amara(=cordiformis)*
Acer saccharinum	*Quercus alba*
Prunus virginiana	" *rubra ambigua*
Platanus occidentalis	*Fagus ferruginea(=grandifolia)*
Juglans cinerea	*Betula alba*

Insects[189]

Saxinis regularis	*Dytiscidæ* species
Donacia elongatula	*Cymindis extorpescens*
Corymbites aethiops (recent)	

Large quantities of fresh-water mollusks are reported from a marl pit on the farm of Fred Conant, at East Shelburne. Four species are listed.[189a]

Lymnea (Galba) elodes	*Planorbis parvus*
Planorbis trivolvis	*Pisidium variabile*

Many years ago, Prime[190] recorded *Pisidium contortum* from postglacial deposits in Pittsfield. A mastodon's tooth[191] was found in a muck bed on a

[188] Sampson, Holyoke Folio, p. 7.

[189] Scudder, Amer. Journ. Sci., (iii), XLVIII, p. 182, Mon. XXIX, U.S.G.S., pp. 740-746.

[189a] Mon. XXIX, U.S.G.S., pp. 738-739.

[190] Mon Amer. Corbic., p. 73.

[191] Hitchcock, Amer. Journ. Sci., (iii), III, p. 146.

farm in the town of Coleraine on the north border of the state. The bones of this animal have also been reported from Northborough, Worcester County.[191a] These appear to be the only records of the presence of this animal within the borders of Massachusetts.

C. CONNECTICUT

Postglacial records of life from land or freshwater deposits are apparently rare from this state. Davis[192] thus comments on a peat deposit: "Near New Haven, in the marshes of Quinnipiac River, is a deposit of excellent brick clay, presumably of glacial origin, over which is superposed a peat bed of varying thickness. The removal of the peat to work the clay bed by the brickmakers has exposed large sections of peat which afford opportunities, unusual in the United States, for studying the history of the beds.

"In a typical section at the brickyard near "Shutzer Park" the peat rests on a thin bed of gravel or sand, on top of which is a forest soil bed, in which there are stumps of trees whose roots penetrate the underlying gravel. Above this woody stratum the peat shows flora changing gradually from forest to fresh-water sedge marsh, then to brackish, and finally to the salt marsh. The stump-bearing layer is now several feet below the tide level of the undisturbed marsh. The clay below the gravel has numerous woody roots much older than those in the gravel."

A few mammalian remains have been recorded from postglacial deposits. The bones of a reindeer, believed to be *Rangifer tarandus*, have been found in the Quinnipiac Valley, two miles south of New Haven. The bones were 7 and 11 feet below the surface.[192a] The most perfect skeleton of a mastodon yet found in New England is reported by Lull[193] from Farmington, near Hartford.

D. IOWA

Along the Missouri River, in Iowa and Nebraska, deposits of alluvium occur of wide extent and great depth. These deposits are largely referable to post-Wisconsin time and their biota may be compared with that found within the borders of the last great ice sheet. Little systematic work has been done to differentiate the biota of the various deposits, for which reason most of the lists of species are unreliable. Shimek, however, has given an excellent account of post-Wisconsin deposits and biota which occur in Harrison and Monona counties. His list of species is repeated below. As is usual with material cast up on the flood plain of a river or stream, it contains both terrestrial and fluviatile species, indiscriminately mixed.[193a]

[191a] Rice, Authors separate, pp. 3-8, 1885.
[192] Bull. Geol. Soc. Amer., XXIV, p. 700, 1913.
[192a] Dana, Amer. Journ. Sci., (iii), X, pp. 354-356.
[193] Bull. Geol. Soc. Amer., XXV, p. 143, 1914.
[193a] Iowa Geol. Surv., XX, pp. 395-396, 405-410.

Vallonia gracilicosta	*Helicina occulta*
parvula	*Galba caperata*
Polygyra hirsuta	" *humilis modicella*
" *monodon*	" *obrussa*
" *multilineata*	" *reflexa*
" *profunda*	*Aplexa hypnorum*
Bifidaria armifera	*Physa gyrina*
" *contracta*	" *integra*
" *pentodon*	*Planorbis antrosus(=bicarinatus)*
Vertigo ovata	" *trivolvis*
" *tridentata*	" *dilatatus*
Vitrea hammonis	" *exacuous*
Euconulus fulvus	" *parvus*
Zonitoides arborea	*Pisidium abditum*
" *minuscula*	" *compressum*
Pyramidula cronkhitei anthonyi(=striatella)	*Sphaerium simile(=sulcatum)*
Helicodiscus parallelus	*Musculium truncatum*
Succinea avara	*Lampsilis anodontoides*
" *ovalis*	*Quadrula lachrymosa*
" *retusa*	Eggs of small snails

The remains of *Bison bison* have also been found in the alluvium at the following localities:

Jordan Township, Monona County, in bank of Beaver Creek.

Hog Creek, Harrison County, in gully.

The bones were associated with antlers and bones of the virginia deer and elk. An old beaver dam was found at a depth of twelve feet in the Monona County exposure. Shells and bits of carbonized wood were also found with the bones, which were buried to a depth of 15 feet in the Monona County locality.[194]

Two miles east of Bellevue,[194a] in a dark silty clay deposit in a low terrace, six species of mollusks occurred. The deposit is believed to be referable to post-Wisconsin time.

Goniobasis virginica	*Planorbis trivolvis*
Campeloma decisa	*Planorbis antrosus(=bicarinatus)*
Physa heterostropha	*Sphaerium striatinum*

Of the above list, *Goniobasis virginica* is certainly an error, that species being confined to the Atlantic drainage. It is possibly a *lapsis pennae* for *Goniobasis livescens*, the common Mississippi Valley form of this genus.

[194] Shimek, Iowa Geol. Surv., XX, pp. 407-410.

[194a] Shaw and Trowbridge, Galena-Elizabeth Folio, p. 7, 1916.

The remains of elephants, mastodons, and other mammals have been noted in several places in Iowa, in strata referable to post-Wisconsin time. Miss Anderson[195] and Dr. Hay[196] mention the following:

Mammut americanum.

Carroll County. Near Carroll, distal end of a tibia (Hay, page 381).

Dallas County. Adel, in peat deposit filling 'kettle-hole' on Wisconsin drift; a complete skeleton (Calvin, Bull. Geol. Soc. Amer., XXII, page 215; Hay, page 382).

Greene County. Scapula and humerus from Rippey. (Hay, page 382).

Elephas primigenius.

Cerro Gordo County. Near Clear Lake, lower jaw; Mason City (T. 76 N., R. 20 W., Sect. 11, Mason Township), molar from Gabler gravel pit (Hay, pages 85, 429).

Floyd County. Marble Rock, teeth and tusk from gravel pit, deposit in Wisconsin valley train (Hay, page 434).

Lyon County. Rock Rapids, atlas in gravel at depth of 5 feet. Vertebrae and distal end of humerus from same sand pit at depth of 28-30 feet in Wisconsin valley train (Hay, page 439).

Sac County. Marble Rock, teeth and tusk from gravel pit, deposit of Wisconsin valley train (Hay, page 434).

Bison bison.

Webster County. Second terrace, at mouth of ravine, two and one-half miles north of Lehigh, under 6 feet of silt. Teeth and other bones with articles of Indian workmanship (Wilder, Geol. Iowa, XII, page 190; Hay, p. 315).

Crawford County. Near Deloit, part of skull in canal excavation for purpose of straightening Boyer River; probably recent (Hay, page 315).

Hardin County. From well near Hubbard, portion of skull (Hay, page 315).

Ovibos moschatus.

Fayette County. Clermont Township, section 35, portion of skull in clay at depth of about 26 feet below the surface (Hay, page 297).

Wapello County. Ottumwa, portion of skull (Hay, page 297).

A goodly number of vertebrate records are known from Iowa, which are in deposits that cannot be certainly placed in any interglacial interval. Many of these are probably of post-Wisconsin age; others have doubtless been carried from interglacial strata and redeposited in the beds of rivers, on sand bars, and in other places. For the sake of completeness, and to call especial attention to these derelicts, these records are here listed (compiled from the lists of Anderson and Hay, in works cited).

[195] Augustana Library Publications, V, 1905.

[196] Hay, Iowa Geol. Surv., XXIII, 1914.

Mammut americanum.

Benton County. From alluvium of Bear Creek, near Shellsburg, rib and tooth. May have been washed from some interglacial deposit. The region is covered with Iowan drift overlying Kansan drift (Anderson, page 25; Hay, page 380).

Clinton County. Molar from near Clinton; near Bryant, tooth in gravel at depth of 8 feet below the surface (Hay, page 380).

Page County. Teeth in Nodaway River near Clarinda (White, Iowa Geol. Surv., I, page 353; Hay, page 78).

Polk County. Molar from vicinity of Des Moines (Hay, page 390).

Van Buren County. Molar from bed of Chequest Creek, near Milton; from near Selma, right humerus (Hay, page 391).

Wapello County. Six miles south of Ottumwa, tusk of proboscidian. reported as mastodon (Kansas City Review Sci. & Ind., III, page 242, 1879; Hay, page 391); near Ottumwa, ribs and innominate bones, the latter from the Des Moines River; from gravels along Des Moines River, near Eldon, a femur (Hay, page 391).

Warren County. Tooth from Limestone Creek, one and one-half miles west of New Virginia (Howe's Annals of Iowa, II, page 102, 1883; Hay, page 391).

Elephas primigenius.

Des Moines County. Near Burlington, molar (Hay, page 432).

Dubuque County. Along Illinois Central Railroad, eleven miles west of city, molar (Hay, page 433).

Fayette County. West Union, molar (Hay, page 433).

Iowa County. Alluvial deposits along Iowa River near Marengo, lower jaw and molars (Hay, page 436).

Linn County. From sand in bed of Cedar Rapids River, near Cedar Rapids (southwest quarter section 27, T. 83 N., R. 7 W.), tooth (Hay, page 438).

Louisa County. Near Wapello, tooth; five miles northwest of Columbus Junction (southwest quarter section 34, T. 76 N., R. 5 W.), teeth from a gully, which possibly came from an interglacial deposit (Hay, p. 438).

Polk County. Des Moines, near Osceola bridge, teeth; gravel pit at north end of Sixth Avenue bridge, teeth and femur (Hay, page 443); Town of Polk, molar (Beyer, Iowa Geol. Surv., IX, page 211; Hay, page 444).

Tama County. Molar in bank of Iowa River, about one and one-half miles south of Tama (Hay, page 447).

Elephas columbi.

Cherokee County. Three miles north of Cherokee, molar, in Turner gravel pit, 16 feet below the surface (Hay, page 429).

Clinton County. Molar from Clinton (Hay, page 430).

Davis County. In Des Moines River, six miles from Floris, molar (Hay, page 432).

Des Moines County. Flint Creek, near Burlington, molar (Hay, page 432).

Montgomery County. Near Red Oak, molar from sand in bed of Nishnabotna River (Hay, page 442).

Polk County. Near Des Moines, molar (Hay, page 444).

Scott County. Big Rock, molar (Hay, page 447).

Proboscidian remains, species undetermined.

Allamakee County. Near Pottsville, in bank of Yellow River, teeth, lower jaw, tusks, scapula, some leg bones and vertebrae (Hay, page 427).

Buchanan County. Five miles east of Winthrop, in peaty layer, head of femur (Hay, page 85).

Butler County. Near pit at Clarksville, portion of tusk (Hay, page 86).

Cedar County. Near Clarence, in bed of small creek (southeast quarter section 6, T. 81 N., R. 1 W.), molars (Norton, Iowa Geol. Surv., XI, page 377; Hay, page 428).

Cherokee County. Tusk in gravel pit of Illinois Central Railroad, on east side of Little Sioux River (Hay, page 430).

Clayton County. Wagner Township (sections 5, 16, 23, T. 94 N., R. 5 W.), teeth (Hay, page 430).

Clinton County. Clinton, tooth and tusk, in Chicago Academy of Sciences.

Dubuque County. Horse Shoe Bluff, three miles below city, tooth (Hay, 43). p.

Ida County. Tooth of proboscidian from Ida Grove (Hay, page 86).

Jackson County. Near Maquoketa, atlas and vertebrae (Anderson, page 27; Hay, page 385).

Jefferson County. Walnut Township (northwest quarter section 28, T. 73 N., R. 8 W.), in bed of Walnut Creek, jaw of *Elephas* (Udden, Iowa Geol. Surv., XII, page 428; Hay, page 437).

Johnson County. Near Iowa City, tusk from bed of Iowa River (Hay, page 437).

Marshall County. Near Albion, in Iowa River (Anderson, page 79; Hay, page 441).

Polk County. Femur in sand bar in Raccoon River (Anderson, page 34; Hay, page 444).

Scott County. From farm near Buffalo, molar and other bones (Hay, page 447).

Lee County. In Sugar Creek, near Melrose, molar (Anderson, page 28; Hay, p. 437).

Story County. Washington Township, near Ames, vertebrae, part of femur and tibia (Stalker, Iowa Geol. Surv., IX, page 210; Hay, pages 82, 390).

Bison species (cf. *bison*).

Black Hawk County. Bank of Cedar River near La Porte City, vertebrae (Hay, page 316).

Guthrie County. Bear Grove, molar (Hay, page 316).

Tilton[196a] reports several vertebrates from terrace deposits south of Des Moines which are thot to be of Wisconsin or early post-Wisconsin age. The following species are mentioned:

Bison (metapodial and astragalus)
Mastodon or Elephant (tusk and large bones)
Rangifer muscatinensis (vertebra and piece of lower jaw)
Symbos cavifrons (atlas)

E. SOUTH DAKOTA

Todd[197] records the presence of the mammoth (*Elephas columbi*) in a high terrace just east of the Big Sioux River, above the falls and opposite the City of Sioux Falls. The deposit is loamy sand, sixty feet above the river. The bones were found six feet beneath the surface of the terrace.

V. THE CHAMPLAIN SUBSTAGE

Following the Algonquin stage, the land was notably depressed and partly submerged by an arm of the sea which filled at least a part of the Ontario basin, extending up the Ottawa Valley past the City of Ottawa, and also occupying the Lake Champlain basin and extending down the Hudson River Valley to meet the sea at New York. It seems evident that the subsidence of the land was rather sudden and the elevation of the land gradual, a condition indicated by the nature and position of the life contained in the deposits, the deep water forms overlying the boulder clay, while the littoral forms are near the top of the strata. Dr. J. W. Dawson has published a section made on Logan's farm which brings out these facts graphically.[198]

Soil and sand	1 ft.	9 in.
Tough, reddish clay	0 "	½ "
Gray sand, with few specimens of *Saxicava rugosa* (=*arctica*) *Mytilus edulis*, *Macoma groenlandica*, and *Mya arenaria*, the valves generally united	0 "	8 "
Tough, reddish clay, with few shells of *Astarte laurentiana* and *Leda portlandica*	1 "	1 "
Gray sand, containing detached valves of *Saxicava rugosa*, *Mya truncata*, *Macoma groenlandica*, *Trichotropis borealis* and *Balanus crenatus*, the shells in three thin layers	0 "	8 "
Sand and clay, with few shells, principally *Saxicava* in detached valves	1 "	3 "
Band of sandy clay, full of *Natica clausa*, *Trichotropis borealis*, *Fusus tornatus*, *Buccinum undatum*, *Astarta laurentiana*, *Balanus crenatus*, etc., sponges and		

[196a] Proc. Iowa Acad. Sci., XXII, pp. 233-236, 1915.
[197] Bull. No. 1, So. Dakota Geol. Surv., pp. 125-126, Bull. 158, U.S. Geol. Surv., p. 85.
[198] Can. Nat., IV, p. 25.

Foraminifera. Nearly all the rare and deep sea shells of this locality occur in this band	0 ft. 3 in.
Sand and clay, a few shells of *Astarte* and *Saxicava*, and remains of sea weeds with *Lepralia* attached; also Foraminifera	2 " 0 "
Stony clay, boulder clay	x " x "
Depth of section	7 " 8½ in.

The abundance and variety of the fauna found in these beds indicate an extensive duration of marine conditions. At several localities, as at Montreal and Logan's Creek, fresh water shells are mingled with the marine species, showing that rivers and streams flowed into the sea, bringing down and depositing these fluviatile species. In the present connection, only those localities will be considered that have produced a mixed fresh water and marine fauna. In the Gulf of St. Lawrence, and on the Atlantic coast from Maine southward, a great many postglacial deposits occur which contain an abundant and varied marine fauna.[199]

[199] See the following papers relating to this subject:
Amer. Nat., V, p. 125, 1871 (Ontario Co.).
Bell, Can. Geol. Surv., Rep. 1879, pp. 1-37 C (p. 32 Hudson's Bay).
Bell Amer. Journ. Sci., (iv), V, pp. 219-228, 1896 (Hudson's Bay).
Bell, Geol. Surv. Can., Rep. Prog., pp. 1-31CC, 1879 (p. 11, Hudson's Bay).
Chalmers, Geol. Surv. Can., An. Rep., VII, 1894, M, 1896, pp. 36, 37, 112, 127, 128, 134 (New Brunswick, etc.).
Clapp, Bull. Geol. Soc. Amer., XVIII, pp. 505-556, 1908 (New England)
Dawson, Amer. Journ. Sci., (ii), XXV, pp. 275-277, 1858 (Montreal).
Dawson, *op. cit.*, XXV, pp. 200-202, 1883 (Ontario).
Dodge, Amer. Journ. Sci., (iii), XLVII, pp. 100-104, 1894 (Massachusetts).
Ells, Geol. Surv. Can., Rep. 1879-1880, pp. 1-47D (New Brunswick).
Ells, *op. cit.* No. 977, pp. 1-46, 1907 (Ontario and Quebec).
Johnston, W. A., Geol. Surv. Can., Memoir 101, pp. 25-32, 1917 (Ottawa).
Little, Bull. Geol. Soc. Amer., XXVIII, pp. 309-322, 1917 (Waterville, Maine).
Low, Geol. Surv. Can., Report, 1890-1891, pp. 1-82 L, 1892 (Quebec).
Low, *op. cit.*, 1887, F, pp. 1-19 (p. 18, Hudson's Bay).
Merrill, Ann. N. Y. Acad. Sci., III, pp. 341-364, 1886 (pp. 354-355, Long Id.)
Packard, Amer. Journ. Sci., (ii), XLI, pp. 30-32, 1866 (Labrador).
Perkins, Rept. State Geol. Vermont, VI, 1907-1908, pp. 76-112, 1908 (Vermont).
Reis, Bull. N. Y. State Mus., No. 12, 1895, pp. 93-262 (p. 103 New York).
Sherman, Amer. Nat., VII, pp. 373-374, 1873 (Maine).
Shimer, Post-Glacial History of Boston, Amer. Journ. Sci., (iv) XL, pp. 437-442, 1915.
Stansfield, J., Geol. Surv. Can., Memoir 73, pp. 65-68, 1915 (Montreal).
Thompson, Amer. Journ. Sci., (ii), IX, p. 262-263, 1850 (Vermont).
Upham, Amer. Journ. Sci., (iii), XXXVII, pp. 359-372, 1889 (Massachusetts).
Upham, *op. cit.*, pp. 100-104 (Massachusetts).
Whiteaves, Ottawa Nat., XX, pp. 214-216, 1907 (Parkenham, Ont.).

A. THE OTTAWA VALLEY

One of the best known localities from which a mixed biota has been obtained is near the mouth of Green's Creek, where it enters the Ottawa River, in the Township of Gloucester, Carlton County, from six to ten miles below the City of Ottawa. The fossil-bearing stratum, the Leda clay, is near the water level and in the fall (usually in September) when the water is low, the shore of the Ottawa River is strewn for a considerable distance with the fossils which are enclosed in hard clay nodules.[200] The following localities, all in the neighborhood of Ottawa, have yielded fossils: Besserer's wharf; creek near bridge at Cyrville; Graham's brickyard, Ottawa East; right bank of Rideau River, near Manotick Road; Gatineau Valley railway, half mile north of Chelsea station; Odell's brickyard, Ottawa East; Wright's brickyard, north of Tétreauville, Hull, Quebec. A very good idea of the life of the Champlain substage may be gained from a study of the fossils assembled in this vicinity. A list of these is given below:

Land and fresh water biota in the vicinity of Ottawa

Terrestrial Plants[201]

Arctostaphylos uva-ursi	*Gramineae* species
Acer saccharinum	*Populus balsamifera*
" *spicatum*	" *grandidentata*
Alnus species	*Potentilla anserina*
Betula lutea	" *norvegica*
Bromus ciliatus	" *canadensis*
Carex magellanica	" *tridentata*
Cyperaceae species	*Thuja occidentalis*
Gaylussacia resinosa	*Trifolium repens*

Fresh Water Plants

Drepanocladus fluitans (=*Hypnum*)	*Potamogeton pectinatus*
Algae species	" *natans*
Brasenia peltata	" *perfoliatus*
Elodea canadensis	" *pusillus*
Equisetum scirpoides	" *rutilus*
" *limosum*	*Typha latifolia?*
" *sylvaticum*	*Vallisneria spiralis*
Drosera rotundifolia	" species

According to Penhallow, the vegetation on the whole is about the same as that now living in the same locality.

Animals (Mollusks)

Planorbis species	*Lymnaea stagnalis appressa*

[200] Dawson, Can. Nat., N. S., III, p. 69; Bell, Geol. Can., pp. 972-973; Can. Nat., V, p. 43; Ami, Rep. Prog., Can. Geol. Surv., 1899, pp. 51-56, G.

[201] Penhallow and Coleman, Rep. Brit. A.A. Sci., 1898, pp. 522-529; 1899, pp. 411-414.

Insecta

Tenebrio calculensis	*Fornax ledensis*
Byrrhus ottawaensis	*Phryganea ejecta*

At Pakenham, about thirty miles west of Ottawa, a deposit of fresh and brackish water mollusks occurs. The section in which these shells occur contains the following strata:

1. Sand and surface soil, about	10 feet	0 inches
2. Clay	10 "	0 "
3. Fine gray sand with shells of *Valvata*, etc	0 "	2 "
4. Clay	1 "	0 "
5. Gray sand, laminated, with *Tellina*	0 "	3 "
6. Clay	0 "	8 "
7. Light gray sand, with *Valvata*, *Sphaerium*, *Amnicola*, *Planorbis* and *Tellina*	0 "	10 "
8. Clay	1 "	2 "
9. Brown sand and layers of clay with *Planorbis*, *Sphaerium*	0 "	4 "

In the bank of a brook emptying into the Mississippi River, two miles below Pakenham, shells occur in a deposit of sand and gravel corresponding to number 7 of the above section. Eight species have been identified.[202]

Valvata tricarinata	*Planorbis parvus*
Amnicola limosa porata	*Galba elodes?*
Planorbis bicarinatus(=*antrosus*)	*Pyramidula cronkhitei anthonyi*
" *trivolvis*	*Tellina groenlandica*(=*Macoma balthica* var. *groenlandica*)

These strata doubtless represent different periods of time as well as varying physical conditions, facts attested by the alternation of beds of clay and sand. The locality was evidently at the mouth of the Mississippi River and the water was fresh or only slightly brackish. The large volume of fresh water which was constantly discharged thru the Nipissing outlet doubtless freshened the sea for a long distance. This whole region possibly formed an estuary.

B. MONTREAL AND VICINITY

At Montreal fresh water shells occur mixed with marine mollusks, in sandy strata, immediately above the Leda clay. As suggested by Bell[203] these shells might have been washed down from fresh water ponds on the top of Montreal Mountain, which rose over 200 feet above the level of the Champlain Sea. This mountain is now 700 feet above the level of the sea and a number of

[202] Dawson, Can. Nat., V, p. 194; IV, p. 36.
[203] Can. Nat., VI, p. 42.

ponds occupy the highest points, and contain a varied molluscan fauna. The fresh water and land forms, as well as the typical marine species found in these deposits, are listed below:

Fresh Water and Land Species	Marine Species
Galba caperata	*Saxicava arctica*[204a]
" *umbrosa* (=*elodes*)	*Macoma groenlandica*
Sphaerium species	*Mya arenaria*
Thuja occidentalis[204]	" *truncata*
Larix americana	*Mytilus edulis*
Picea nigra	*Zostera marina*
Populus grandidentata	*Algae*
Menyanthes trifoliata	

The marine species are all shallow water forms, indicating that the deposit is the Saxicava sand. In the clay beneath this deposit *Leda portlandica* was found, indicating a period of deeper water (the Lada clay).

C. LAKE ST. JOHN

Unio shells have been found in a brickyard at Reberval, on Lake St. John. The strata of this region are distributed as follows:[205]

1. Peat and bogs and decomposing vegetable matter.
2. Lucustrine and fluviatile sands and clays sometimes containing shells of Unio. Except for the presence of these shells it would be difficult to distinguish the sands of this series from the Saxicava sands.
3. Saxicava sand and Leda clay.
4. Boulder clay.
5. Decomposed rock in situ.

On the west side of Lake St. John, fresh water shells have been observed in clay beds at heights of 25 and 30 feet above the lake, which is 341 feet above sea level. Marine shells have been observed in deposits at Chicoutimi, some distance down the Saguenay River. The lacustrine deposits evidently represent a time later than the Champlain submergence when Lake St. John stood some 40 or 50 feet higher than at present. It is probable that the land had been elevated sufficiently to cause the sea to retreat far enough from this region to hold the accumulating fresh water at this height. In other words, these strata were formed during the waning of the Champlain substage.

[204] In Leda clay at Mile End; see Geol. Can., p. 976.
[204a] For a full list of the Marine fossils from this locailty, see Stansfield, '15, pp. 65-67.
[205] Chalmers, An. Rep. Can. Geol. Surv., XVI, 1904, pp. 250-263A, 1906.

D. LAKE CHAMPLAIN VALLEY

Near Clarenceville, about four miles north of the Vermont boundary line, beds of fresh water shells occur about ten feet above Lake Champlain. The specimens are mixed in sandy clay as follows:[206]

Lampsilis ventricosa	*Macoma groenlandica*
Eurynia recta	*Mya arenaria*
Lymnaea species	

As Lake Champlain was first a glacial lake and later a marine estuary, it is possible that the fresh water shells occupied the former and the marine shells the latter body of water. Additional stratigraphical data and material are needed to satisfactorily determine this point.

The marine deposits of the Champlain Valley have not been studied as thoroughly as have those of the St. Lawrence Valley. Evidences of the presence of the sea have been observed in the northern part of Vermont and New York, bordering Lake Champlain. Fossil shells, as well as other marine life (including the bones of a whale), have been noted at the following localities:[207]

Vermont

East Panton (Elgin Spring)	West Milton
Vergennes	Checkerberry Village
Shelburne (Morses and Shelburne Falls)	Swanton
Charlotte (Mutton Hill)	Burlington
Colchester (Mallett's Bay)	Panton

New York

Port Kent, Clinton County	Norwood
Plattsburgh, Clinton County	Willsboro
Ogdensburg	Crown Point peninsula
Freydenburg's Mills on the Saranac	
1¼ miles below Mooer's Forks, at the bend of the Big Chazy.	

E. MARINE DEPOSITS OF THE ST. LAWRENCE VALLEY

Thruout the St. Lawrence Valley, east of Ottawa and Montreal, many deposits occur which contain the remains of an abundant and varied fauna. None of these, as far as at present known, contain fresh water mollusks. The most important localities at which marine fossils have been found are,

Beauport, near Quebec.[208]

[206] Dawson, Can. Nat., V, p. 195.

[207] Baldwin, Amer. Geol. XIII, pp. 170-184; Woodworth, Bull. N. Y. State Museum, No. 83, p. 49; No. 84, pp. 208-215.

[208] Dawson, Can. Nat., II, p. 408; Billings, Can. Nat., I, p. 338.

Cacouna, and Rivière-du-Loup.[209]

Tattagouche River, near Bathurst, N.B.[210]

Bay de Chaleur, Bonaventure District, Quebec.[211]

Near Greenville on the River Rouge.[212]

One of the most westerly points at which marine fossils have been found appears to be Renfrew, Ontario, from which deposits the following species are recorded:[213]

Saxicava arctica
Macoma balthica groenlandica
Mallotus villosus[214]

F. NEW BRUNSWICK

Marl deposits occur in New Brunswick and on Anticosti Island, but no data are available concerning their contents. They are doubtless of post-Champlain origin. Dall[215] has described *Galba anticostiana* from Marl Lake, Anticosti Island, associated with *Galba galbana*. Ells[216] refers to a deposit near Belledune Point, which is 2 feet thick and is overlaid by 5 feet of peat. Fresh water shells were found in the marl bed. Similar deposits occur two miles north of Charlo Station, in the bed of a small lake.

G. NOVA SCOTIA

The mastodon ranged as far as Nova Scotia in post-Wisconsin time, the bones of this animal having been found near Lower Middle River settlement, Victoria County, Cape Breton Island. From a stratum of sand and gravel beneath 5 inches of meadow soil a molar tooth was found at Baddeck, Victoria County, on the northwest side of Little Bras d'Or Lake.[217]

VI. Wisconsin Loess

Both the early and late Wisconsin till sheet bear evidences of loess deposition, clearly showing that the agencies which formed this characteristic deposit have been more or less active thruout the entire Pleistocene period. The

[209] Dawson, Can. Nat., N. S., II, p. 85.
[210] Paisley, Can. Nat., N. S., VII, pp. 41, 268.
[211] Chalmers, Can. Nat. N. S., X, p. 193; Matthew, *op. cit.*, VIII, p. 104.
[212] Geol. Canada, p. 973.
[213] Billings, Can. Nat., I, pp. 338-346.
[214] Also found at Flat Rapids, Madawaska River.
[215] Land and Fresh Water Mollusks, p. 79.
[216] Geol. Surv. Can., Rep., 1879-1880, p. 42.
[217] Piers, Proc. & Trans. Nova Scotia Inst. Sci., XIII, pt. 2, pp. 167-168.

Wisconsin loess, however, is very scanty when compared with the great loess deposits of the interglacial intervals.

A. IOWA

In Clay and Obrien counties, northwest Iowa, on the edge of the early Wisconsin till, loess occurs and varies from several inches to some feet in thickness. No mollusks are reported.[218]

B. ILLINOIS

The early Wisconsin drift bordering the Illinois River from Peoria to Hennepin received a partial covering of loess.[219] This loess mantle has an average thickness of 2 to 6 feet, and in some places attains a thickness of 10 to 14 feet. The bulk of the thicker deposits is a buff-colored calcareous silt, often containing lime concretions and the shells of mollusks, thus closely resembling the loess of Iowa. The weathered surface is brown and is leached to a depth of from 2 to 4 feet. No lists of the particular species contained in these deposits has been seen. Near Palos Park, Cook County, a loess deposit occurs but no fossils have been observed.[220]

C. WISCONSIN

Loess deposits of late Wisconsin age have been reported from Wisconsin by Prof. Salisbury.[221] Near Green Lake, Green Lake County, about two miles northeast of the village of Dartford, the loess rests on Wisconsin drift and is 150-200 feet above Green Lake. This loess contains no fossils, but at the west end of the lake, in section 4, on a slope at a lower level, facing the lake, the loess contains both concretions and gastropod shells. The character of the mollusks is not stated and no list is given. Near Devil's Lake, loess occurs, but without evidences of life.

At Ablemans, eight miles west of the Wisconsin moraine, in a ravine tributary to the Baraboo River, the loess is rich in concretions and gastropod shells. The bones of a small animal were also found 10 feet below the top of the loess. At Logansville the clay in the valley is somewhat loess-like, is distinctly stratified, and contains shells.[222] This deposit is probably not true loess, but silt formed by streams.

[218] Geol. Surv. Iowa, XI, p. 485.
[219] Barrows, Ill. State Geol. Surv., Bull. 15, p. 48.
[220] Personal communication from Dr. W. W. Atwood.
[221] Journ. Geol., IV, pp. 929-937, 1896.
[222] Salisbury, *op. cit.*, p. 934.

VII. Systematic Catalog of the Biota at Present Known from the Postglacial Deposits Considered in this Work[223]

PLANTS

BRYOPHYTA

Hypnaceae

Drepanocladus fluitans (L.) Warnst.
Plagiothecum denticulatum roseanum (Hampe) B. & S.

Characeae

Chara species

DIVISION I. PTERIDOPHYTA

Family Equisetaceae

Equisetum sylvaticum L.
" *fluviatile L.* (=*limosum L.*)
" *scirpoides* Michx.

Family Lycopodiaceae

Lycopodium selago L.

DIVISION II. SPERMATOPHYTA

GYMNOSPERMAE

Family Pinaceae

Pinus rigida Mill.
" *taeda* L.
Picea mariana (Mill.) BSP. (=*Picea nigra* Link)
" *canadensis* (Mill.) BSP.
Larix laricina (DuRoi) Koch. (=*Larix americana* Michx.)
Abies balsamea (L.) Mill.
Taxodium distichum (L.) Richard
Thuja occidentalis L.
Juniperus virginiana L. (?)

ANGIOSPERMAE

Family Typhaceae

Typha latifolia L.

Family Najadaceae

Potamogeton natans L.
" *perfoliatus* L.
" *pusillus* L.
" *rutilus* Wolfgang
" *pectinatus* L.
Najas sp.

Family Hydrocharitaceae

Elodea canadensis Michx.
Vallisneria spiralis L.

[223] Extinct species are preceded by an *.

Family Gramineae

Oryzopsis asperifolia Michx.

Family Cyperaceae

Carex paupercula irrigua (Wahlenb.) Fernald. (=*magellanica* Man.)
Carex species
Scirpus species

DICOTYLEDONEAE

Family Salicaceae

Salix uva-ursi Pursh.
Populus grandidentata Michx.
" *balsamifera* L.

Family Juglandaceae

Juglans cinera L.
Carya cordiformis (Wang.) K. Koch.
" *glabra* (Mill.) Spach.?

Family Betulaceae

Betula lutea Michx.
" *alba* L.
Alnus species

Family Fagaceae

Fagus grandifolia Ehrh.
* *Quercus marcyana* Penhallow
" *alba* L.
" *rubra ambigua* (Michx.) Fernald
" *phellos* L.

Family Polygonaceae

Oxyria digyna (L.) Hill

Family Nymphaeceae

Brasenia schreberi Gmelin (=*peltata* Pursh.)
Nymphaea advena Ait.

Family Ranunculaceae

Ranunculus aquatilis capillaceus DC.

Family Droseraceae

Drosera rotundifolia L.

Family Platanaceae

Platanus occidentalis L.

Family Rosaceae

Potentilla monspeliensis norvegica (L.) Rydb.
" *tridentata* Ait.
" *anserina* L.
" *canadensis* L.
Prunus virginiana L.

Family Leguminosae

Trifolium repens L.

FAMILY ACERACEAE

Acer spicatum Lam.
" *saccharinum* L.

FAMILY VITACEAE

Vitis æstivalis Michx.
* *Vitis pseudorotundifolia* Berry

FAMILY RHAMNACEAE

Zizyhus species

FAMILY VIOLACEAE

Viola palustris L.

FAMILY ERICACEAE

Vaccinium uliginosum L.
" *oxycoccus* L.
Rhododendron lapponicum (L.) Wahlenb.
Arctostaphylos alpina (L.) Spreng
" *uva-ursi* (L.) Spreng
Gaylussacia baccata (Wang.) C. Koch. (=*resinosa* T.&G.)

FAMILY GENTIANACEAE

Menyanthes trifoliata L.

ANIMALS

MOLLUSCA

CLASS PELECYPODA

ORDER PRIONODESMACEA

FAMILY UNIONIDAE

Fusconaja undata (Barnes)
" *solida* (Lea)
Crenodonta peruviana (Lam.) = *plicata*, Authors
" *undulata* (Barnes)
Quadrula pustulosa (Lea)
" *pustulosa schoolcraftensis* (Lea)
" *lachrymosa* (Lea)
" *metanevra* (Raf.)
Rotundaria tuberculata (Rafinesque)
Plethobasus æsopus (Green)
Pleurobema coccineum (Conrad)
" *coccineum magnalacustris* (Simp.)
Elliptio crassidens (Lam.)
" *gibbosus* (Barnes)
" *complanatus* (Dillwyn)
Lasmigona compressa (Lea)
" *costata* (Rafinesque)
Anodontoides subcylindraceus (Lea)
Anodonta cataracta Say (=*fluviatilis*)
" *grandis* Say
" *grandis footiana* Lea
" *marginata* Say (=*fragilis*)
Alasmidonta marginata (Say)
" *calceola* (Lea)
Obovaria circula (Lea)
" *ellipsis* (Lea)
Obliquaria reflexa (Rafinesque)
Amygdalonajas elegans (Lea)
Nephronajas ligamentina (Lam.)
Proptera alata (Say)
Eurynia iris (Lea)
" *ellipsiformis* (Conrad)
" *recta* (Lamarck)
Lampsilis luteola (Lam.)
" *ventricosa* (Barnes)
" *anodontoides* (Lea)

ORDER TELEODESMACEA

Family Sphaeriidae

Sphaerium simile (Say) = *sulcatum* (Lam.)
" *striatinum* (Lamarck)
" *stamineum* (Conrad)
" *stamineum wisconsinensis* Sterki
" *acuminatum* (Prime)
" *solidulum* (Prime)
" *torsum* Sterki
" *levissimum* Sterki
" *flavum* (Prime)
" *emarginatum* (Prime)
" *rhomboideum* (Prime)
" *occidentale* (Prime)
Musculium secure (Prime)
" *transversum* (Say)
" *truncatum* (Linsley)
" *partumeium* (Say) = *orbicularis* Barrett
" *rosaceum* (Prime)
Pisidium abditum (Haldeman)
" *adamsi* (Prime)
" *adamsi affine* Sterki
" *compressum* (Prime)
" *compressum confertum* Sterki
" *compressum laevigatum* Sterki
" *compressum illinoisense* Sterki
" *contortum* (Prime)
" *costatum* Sterki
" *idahoense* Roper
Pisidium fallax Sterki
" *kirklandi* Sterki
" *mainense* Sterki
" *medianum* Sterki
" *medianum minutum* Sterki
" *milium* (Haldeman)
" *noveboracense* (Prime)
" *ohioense* Sterki
" *pauperculum* Sterki
" *politum* Sterki
" *politum decorum* Sterki
" *roperi* Sterki
" *rotundatum* (Prime)
" *sargenti* Sterki
" *scutellatum* Sterki
" *splendidulum* Sterki
" *superius* Sterki
" *tenuissimum* Sterki
" *tenuissimum calcareum* Sterki
" *trapezoideum* Sterki
" *triangulare* Sterki
" *ultra-montanum* (Prime)
" *variabile* (Prime)
" *ventricosum* (Prime)
" *ventricosum costatum* Sterki
" *vesiculare* Sterki?
" *virginicum* (Gmelin)
" *walkeri* Sterki

CLASS GASTROPODA

ORDER PROSOBRANCHIATA

Family Helicinidae

Helicina occulata (Lamarck)

Family Pleuroceridae

Pleurocera subulare (Lea)
" *elevatum* (Say)
Goniobasis livescens (Menke)
" *depygis* (Say)
" *livescens niagarensis* (Lea)
" *haldemani* Tryon

Family Amnicolidae

Amnicola limosa (Say)
" *limosa porata* (Say)
" *limosa parva* (Lea)
" *cincinnatiensis* (Lea) = *sayana* Anth.
" *emarginata* Küster = *obtusa* Lea
" *lustrica* Pilsbry
" *letsoni* Walker
Amnicola walkeri Pilsbry
" *galbana* (Say)
Paludestrina nickliniana (Lea)
Somatogyrus integer (Say)
" *subglobosus* (Say)
Pomatiopsis lapidaria (Say)
Pyrgulopsis scalariformis Wolf

Family Viviparidae

Vivipara subpurpurea (Say)
" *intertexta* (Say)
Campeloma decisum (Say)
Campeloma integrum (DeKay)
" *integrum obesum* (Lewis)
" *subsolidum* (Anthony)
" *subsolidum exilis* (Anthony)?

Family Valvatidae

Valvata sincera Say
" *lewisii* Currier
" *bicarinata* Lea
" *bicarinata perdepressa* Walker
" *obtusa* Drap?
Valvata tricarinata Say
" *tricarinata confusa* Walker
" *tricarinata simplex* Gould
" *tricarinata unicarinata* DeKay
" *tricarinata infracarinata* Vanatta

ORDER PULMONATA

Family Physidae

Physa ancillaria Say
" *warreniana* Lea
" *heterostropha* Say
" *integra* Haldeman
" *niagarensis* Lea
" *sayii* Tappan
Physa walkeri Crandall
" *gyrina* Say
" *gyrina hildrethiana* Lea
" *elliptica* Lea
" *aplectoides* Sterki
Aplexa hypnorum (L.)

Family Ancylidae

Ancylus parallelus Haldeman
" *rivularis* Say
" *kirklandi* Walker
Ancylus fuscus Adams
Gundlachia species

Family Planorbidae

Planorbis trivolvis Say
" *binneyi* Tryon
" *campanulatus* Say
" *antrosus* Conrad = *bicarinatus* Say
" *antrosus striatus* Baker
" *antrosus angistomus* Haldeman
" *crista* Linn?
" *crista cristatus* Drap.
" *rubellus* Sterki
Planorbis exacuous Say
" *deflectus* Say
" *hirsutus* Gould (= *albus* Müller?)
" *altissimus* Baker
" *parvus* Say
" *parvus urbanensis* Baker
" *umbilicatellus* Cockerel
Segmentina armigera (Say)

Family Lymnaeidae

Lymnaea stagnalis appressa (Say)
Pseudosuccinea columella (Say)
Acella haldemani (Desh.) Binney.
Galba caperata (Say)
" *parva* (Lea) = *tazewelliana* Wolf
" *humilis modicella* (Say)
" *humilis rustica* (Lea)
" *obrussa* (Say) = *desidiosa* Authors
" *obrussa decampi* (Streng)
" *obrussa exigua* (Lea)
Galba galbana (Say)
" *dalli* (Baker)
* " *anticostiana* (Dall)
* " *bakeri* (Walker)
" *palustris* (Müller)
" *reflexa* (Say)
" *nashotahensis* (Baker)
" *catascopium* (Say)
" *emarginata canadensis* (Sowerby)

Family Auriculidae

Carychium exiguum (Say)
Carychium exile H.C. Lea.

Family Vallonidae

Vallonia parvula Sterki
Vallonia pulchella (Müller)
Vallonia gracilicosta Reinh.

Family Pupillidae

Gastrocopta contracta[224] (Say)
" *tappaniana* (Adams)
" *pentodon* (Say)
" *corticaria* (Say)
" *armifera* (Say)
Pupoides marginatus (Say)
Vertigo milium Gould.
" *ovata* Say
" *morsei* Sterki
" *tridentata* Wolf
" *elatior* Sterki
Strobilops labyrinthica (Say)
" *affinis* Pislbry

Family Succineidae

Succinea ovalis (Say) = *obliqua* Say.
" *avara* Say
Succinea retusa Say

Family Endodontidae

Punctum pygmæum (Drap.)
Sphyradium edentulum (Drap.)
Helicodiscus parallelus (Say)
Pyramidula alternata (Say)
" *solitaria* (Say)
" *perspectiva* (Say)
" *cronkhitei anthonyi* Pislbry

Family Zonitidae

Gastrodonta ligera (Say)
Zonitoides minscula Sterki
" *laeviscula* Sterki
" *arborea* (Say)
Euconulus fulvus (Müller)
" *chersinus* (Say)
" *chersinus polygyratus* (Pilsbry)
Euconulus sterkii (Dall)
Vitrea hammonis (Ström.)
" *wheatleyi* (Bland)
" *indentata* (Say)
" *rhoadsi* Pilsbry
Omphalina fuliginosa (Griffith)

Family Limacidae

Agriolimax campestris (Binney)
Limacid, species indet.

Family Circinaridae

Circinaria concava (Say)

Family Helicidae

Polygyra monodon (Rackett)
" *hirsuta* (Say)
" *mitchelliana* (Lea)
" *clausa* (Say)
" *thyroides* (Say)
" *elevata* (Say)
" *multilineata* (Say)
" *zaleta* (Binney) = *exoleta* Binn.
" *pennsylvanica* (Green)
Polygyra albolabris (Say)
" *albolabris dentata* (Tryon)
" *sayana* Pils. = *sayi* (Binn.)
" *profunda* (Say)
" *inflecta* (Say)
" *fraudulenta* Pilsbry
" *tridentata* (Say)
" *palliata* (Say)
Eggs of land snail.

[224] This genus was previously known as *Bifidaria*. *Gastrocopta* is an earlier name.

ARTHROPODA

CLASS CRUSTACEA

ORDER OSTRACODA

Cypris species

ORDER DECAPODA

Cambarus blandingi acutus (Girard)

CLASS INSECTA

ORDER COLEOPTERA

Family Byrrhidae

* *Byrrhus ottawaensis* Scudder

Family Chrysomelidae

* *Saxinis regularis* Scudder

* *Donacia elongatula* Scudder

" *proxima* Kirby

Family Elateridae

* *Fornax ledensis* Scudder

Corymbites aethiops Hbst?

Family Tenebrionidae

* *Tenebrio calculensis* Scudder

Family Carabidae

* *Cymindis extorpescens* Scudder

Family Dytiscidae

Species indet.

ORDER TRICHOPTERA

Family Phryganeidae

* *Phryganea ejecta* Scudder

ORDER DIPTERA

Unnamed fragments

VERTEBRATA

CLASS PISCES

Family Amiidae

Amia calva Linn.

Family Siluridae

Fragments of undetermined species

Family Centrarchidae

Lepomis species

CLASS AVES

Family Anatidae

Mergus serrator (Linn.)

CLASS MAMMALIA

Family Megatheriidae

* *Megalonyx jeffersonii* (Desmarest)

Family Tayassuidae

* *Platygonus compressus* LeConte
* *Mylohyus nasutus* (Leidy)

Family Cervidae

Odocoileus virginianus (Zimmermann)
Cervus canadensis Erxleben
Rangifer caribou (Gmelin)
* " *muscatinensis* Leidy
* *Cervalces scotti* Lydekker
* " *borealis* Bensley

Family Bovidae

* *Symbos cavifrons* (Leidy)
Ovibos moschatus Zimmermann
* *Boötherium sargenti* Gidley
* *Bison latifrons* (Harlan)
" *bison* (Linn.)

Family Elephantidae

* *Mammut americanum* (Kerr)
* *Elephas columbi* Falconer=*jacksoni* and *americanus.*
* " *primigenius* Blumenbach

Family Muridae

Fiber zibethicus (Linn.)

Family Castoridae

Castor canadensis Kuhl

Family Castoroididae

* *Castoroides ohioensis* Foster

Family Canidae

Canis latrans Say

VIII. Summary

The data embodied in the previous pages may be summarized under four heads: 1. Duration of Glacial Lakes; 2. Repopulation of the Glaciated Area; 3. Variation in Climate as evidenced by the Biota; and 4. Percentage of Living and Extinct Species; the Wabash Fauna.

1. Duration of Glacial Lakes

It is believed that the Glacial Lakes, while but temporary from a geological standpoint, still persisted for a period sufficiently long enough to allow living organisms to occupy them and become well established. The length of time was also sufficient to permit the building up of huge beaches and the cutting

of tall cliffs. The early lakes were probably of short duration and of fluctuating size, but the later ones, especially the larger lakes in the Huron-Erie-Ontario and Michigan basins, existed for a long period of time.

Of the Nipissing beach Taylor says,[225] "It is altogether the most remarkable littoral feature of the Great Lake region. It is a shore line well advanced toward old age. All other beaches are youthful in comparison. . . . Instead of the slender spits and barrier bars of the Algonquin and the other beaches, the Nipissing has what may be called barrier plains, made up of many, sometimes forty or fifty, massive beach ridges laid one against the other. Many bays were entirely filled with these beach plains and others were cut off, so as to form small littoral lakes. Some of these plains are a mile and a half wide. In some instances the old deltas of other beaches are large and conspicuous, but the constructive products of wave action have no comparison to those of the Nipissing beaches."

2. REPOPULATION OF THE GLACIATED AREA

It may be stated without fear of contradiction that the Wisconsin ice cap absolutely exterminated all life within the area covered by this huge glacier.[226] The area covered by this drift sheet is shown in Plate LVI. In the Great Lakes region the return of the fresh water life could be made only by way of the larger streams forming outlets from the glacial lakes, such as shown in Plates L and LI. From the Mississippi Valley the biota reached Lake Erie via the Fort Wayne outlet; Lake Michigan by the Chicago outlet; Lake Superior by the St. Croix outlet; and Lake Agassiz by the Lake Traverse outlet. An outlet from Green Bay, via the Wisconsin and Fox rivers is also believed to have afforded means for reaching this portion of Lake Michigan.

The data considered in the previous pages show conclusively that the Chicago outlet was used by the fresh water biota to reach the Lake Michigan basin, and that the Lake Huron basin was reached via the Grand River outlet. No direct data has been seen relative to fossiliferous deposits in the Fort Wayne outlet, but such deposits undoubtedly exist and will some day be brought to light. It is believed by some biologists, including the writer, that this outlet was used in restocking the waters of Lake Erie.[227]

The present distribution of the naiad fauna of the Great Lakes, as well as the distribution of the fossil fauna, points conclusively to a postglacial

[225] Amer. Geol. XVII, pp. 398.

[226] Scharff, in his work "Distribution and Origin of Life in America" states his belief that there was an unglaciated region in central North America, where a part of the fauna found refuge during this cold period. He believes that the peculiar naiad fauna of Lake Erie is a relict. Studies in the geology, as well as the present distribution of the naiad fauna, fail to provide data for this theory.

[227] See Walker, The Nautilus, XXVII, Numbers 2, 3, 4, 5, 1903.

migration also from the southeast, possibly by way of the Mohawk–Trent outlet (Plate LII), at which time certain species characteristic of the Atlantic fauna migrated into the Huron basin and have now reached as far westward as eastern Lake Superior and the Upper Peninsula of Michigan. *Elliptio complanatus*, a member of the Atlantic fauna, is found as a fossil as far west as Simcoe District, Ontario (town of Angus).

The two faunas, the Mississippi Valley and the Atlantic coastal plain, as represented by fossil examples, may be tabulated as follows. The Atlantic fauna invaded the territory north and east of Lake Superior, the Lake Huron region, a portion of the Northern Peninsula of Michigan and the territory east of central New York.

Mississippi Valley	Atlantic Coast
Fusconaja undata	....
" *solida*	....
Crenodonta peruviana	....
" *undulata*	....
Quadrula pustulosa	....
" *pustulosa schoolcraftensis*	....
" *lachrymosa*	....
Rotundaria tuberculata	....
Pleurobema coccineum	....
" *coccineum magnalacustris*	....
Elliptio crassidens	....
" *gibbosus*	....
....	*Elliptio camplanatus*
Symphynota compressa	....
" *costata*	....
Anodonta grandis	....
" *grandis footiana*	....
" *marginata*	*Anodonta marginata*
....	" *cataracta*
Anodontoides subcylindraceus	....
Alasmidonta marginata	....
" *calceola*	....
Obovaria circula	....
" *ellipsis*	....
Obliquaria reflexa	....
Amygdalonajas elegans	....
Proptera alata	....
Eurynia iris	....
" *ellipsiformis*	....
" *recta*	....
Lampsilis luteola	*Lampsilis radiata*
" *ventricosa*	....
" *anodontoides*	....

It will be seen that the greater number of species is characteristic of the Mississippi Valley, 16 genera and 31 species being from this region, while but 3 genera and 4 species are from the eastern fauna, and only 3 of these are strictly confined to the Atlantic faunal region. The inference to be drawn from these data is obvious and is in complete accord with Dr. Walker's remarks on the distribution of the recent naiades of the same region.[228] Equally interesting data could be provided from a study of the distribution of other groups of animals.

3. VARIATION IN CLIMATE AS EVIDENCED BY THE BIOTA

Some years ago, Dr. T. C. Chamberlin[229] made the following statement, "The to-and-fro movement of the faunas and floras introduced into the record exceptional superpositions of faunas upon one another. The succession was orderly but unusual. Where a complete record could be made, as in a depositing tract just outside the limit of the invading ice, the full series for the advancing stage of an ice invasion should embrace a succession of faunas and floras ranging from the temperate, through cold-temperate and sub-arctic, to the extreme arctic types, while a full record of the retreating stages of the ice should embrace the same series reversed."

As remarked by Dr. Chamberlin, this theoretical succession is rarely perfectly represented. In several places, however, as at Chicago and some other places, a partial record has been preserved, and a characteristic biota is represented, abundantly supporting the statement of Dr. Chamberlin. At Chicago a series of deposits are superimposed one upon another, which contain the biota of several climates. The lowest, and therefore the oldest of the retreating series, contains two spruces, *Picea canadensis* and *Picea mariana*, a tamarack, *Larix laricina*, the balsam fir, *Abies balsamea*, the arbor vitae, *Thuja occidentalis*, and the balsam poplar, *Populus balsamifera*, as well as a molluscan fauna characteristic of a cold-temperate or even subarctic zone. The deposit overlying this cold fauna is filled with an abundant and varied fauna characteristic of a temperate climate as warm as, or even warmer, than that of today.

That there was a period during which the climate of the region immediately adjacent to the lower Great Lakes was somewhat warmer than at the present time is apparently evidenced by the presence of a peccary (*Platygonus compressus*) in both Michigan and northern New York. The *Megalonyx* also lived in Ohio. Deposits in northern New Jersey contain a flora the species of which indicate a period of higher temperature. Of the 9 species represented in this deposit, 4 do not now range north of southern Maryland, and 1 (Zizyhus) is mainly tropical and is not now represented in the northern coastal plain (Vide

[228] Nautilus, XXVII, pp. 21, 30, et seq.

[229] Chamberlin and Salisbury, Geology, III, p. 487.

Berry). In Massachusetts a fossil flora indicates a subarctic climate, evidently living not far south of the retreating glacier. A later deposit, not far distant, indicates a temperate climate. The variation of climatic conditions as the huge glacier retreated to the northward, is thus indicated by the remains of life contained in the deposits left by the glacial waters.

4. PERCENTAGE OF LIVING AND EXTINCT SPECIES

Sixty-eight species of plants and 271 species of animals are represented in the deposits overlying the Wisconsin drift. An analysis of this biota shows that of the plants 66 are still living and 2 are extinct. Of the animals 245 are recent and 29 are extinct. Among the animals, the mollusks have 231 living and 7 extinct, while the insects have 7 extinct and 3 living, and the mammals have 13 extinct and 8 living species. It will be noted that the insects and the mammals, the highest and most complex types of the invertebrate and the vertebrate branches of the animal kingdom, have passed thru the greatest changes during the postglacial period, the majority of the species represented being extinct. The plants and the mollusks show little or no change, the percentage of extinct species being very small.

5. THE WABASH FAUNA

Recently, Dr. O. P. Hay[230] proposed the name Wabash beds for the deposits laid down subsequent to the retreat of the Wisconsin ice sheet, and to the biota he gave the name of Wabash fauna, believing that the period between the waning of the ice sheet and the historical period should bear a name and be equivalent in value to the interglacial periods between the different ice sheets. The proposed distinction seems appropriate, especially when considered in relation to the insect and mammal faunas, which, as we have shown, contain a large percentage of extinct species. The same relation between the plants and the mollusks, and the insects and mammals continues thruout the interglacial periods, the former consisting largely of species now living while the latter are made up largely of species now extinct.

Among the vertebrates, the fish and birds are too poorly represented to permit of generalizations. Those species identified are all living. Of the mammals it is to be noted that the megalonyx, peccary, extinct musk-ox and bison, mastodon, two mammoths, two extinct elk (*Cervalces*), an extinct caribou, and the giant beaver lived and roamed the territory left bare by the retreating glacier for a long period after the ice had entirely disappeared from the Great Lakes region, and it would be difficult indeed to declare with accuracy just how recently some of these animals formed a part of the existing fauna (see Chapter XII, page 371).

[230] Smith, Mis. Coll., No. 20, p. 13, 1912.

The biota cataloged in the previous pages forms but a small part of the life which actually invaded the englaciated territory. Many additional species will doubtless be found as more attention is given to the subject and more systematic work is carried on. Careful discrimination of the different strata of old lake deposits will add greatly to our knowledge concerning the succession of faunas, and it will be found that the greatest results can be obtained by studying the material from the modern ecological standpoint, as was the case with the Chicago deposits described in Chapters I, II, and III.

PART II

REVIEW OF OUR PRESENT KNOWLEDGE CONCERNING THE LIFE OF THE GLACIATED AREA DURING THE PLEISTOCENE OR GLACIAL PERIOD

CHAPTER V

PREGLACIAL CONDITIONS AND LIFE

It is believed that the area covered by the great ice sheets had been subjected to subaerial conditions since the close of the Paleozoic Era. During this vast period of time there occurred changes of level, resulting in deepening or otherwise modifying the valleys cut by erosion and subjected to atmospheric agencies. Previous to the Pleistocene Period, the country embraced in the northern and northeastern portion of the United States, as well as in British America, had been reduced to a condition of great maturity, or, in other words, base leveled, producing a grandly rolling surface, covered with a deep residual soil and subsoil.

1. Ancient Drainages

a. THE BASINS OF THE GREAT LAKES AND THE BURIED RIVER VALLEYS

For many years the belief was held by the majority of geologists that the basins of the Great Lakes—Superior, Michigan, Huron, Ontario, Erie—had been scooped out by the great continental glacier. Data supplied by lake soundings and well borings have clearly indicated that this theory can no longer be held, and that these lake basins represent ancient river valleys, occupied by a great river system comparable to that of the Mississippi in magnitude. These valleys and their connections and tributaries have been carefully worked out by Prof. J. W. Spencer, and others, and are graphically shown on the accompanying map.[1] (Plate LIV).

[1] J. W. Spencer, The Falls of Niagara. Can. Geol. Surv., 1907, pp. 391-412.
Discovery of the Preglacial Outlet of the Basin of Lake Erie.
Proc. Amer. Phil. Soc., XIX, pp. 300-337; Second Geol. Surv. Penn., Rept. Progress, 1879, QQQQ, pp. 357-406, 1881.
High Continental Elevation preceding the Pleistocene Period.
Bull. Geol. Soc. Amer., VI, pp. 141-166, 1895.
Relationship of the Great Lake Basins to the Niagara Limestone.
Bull. Geol. Soc. Amer., XXIV, pp. 229-232, 1913.
Newberry, On the Origin and Drainage Features of the Basins of the Great Lakes. Proc. Amer. Phil. Soc., XX, pp. 91-95, 1883.

Toward the end of the Pliocene Period the entire country experienced a considerable elevation, amounting in places to 2500 or 3000 feet, and in the Grand Canyon region to as much as 6000 feet.[2] This elevation initiated a fresh cycle of erosion, which was not finished at the beginning of the Glacial Period. The Grand Canyon is an erosional result of this uplift. On the Atlantic coast the evidences of such an uplift are found in the submerged canyon of the Hudson River, which extends to the edge of the steep continental slope, about 105 miles from Sandy Hook. "The outermost twenty-five miles are a submarine fjord three miles wide and from 900 to 2250 feet in vertical depth measured from the crests of its banks, which with the adjacent flat area decline from 300 to 600 feet below the present sea level" (Upham). Spencer[3] later stated that the floor of this canyon is 8736 feet below the level of the sea, and the walls, at the deepest sounding, are some 4000 feet high (or deep), rivaling in magnitude even the Grand Canyon of Arizona. Stoller[2a] states that the Hudson from Corinth eastward flows in a channel cut in an interglacial interval. "During an interglacial epoch a stream from the north, following the course of the preglacial Luzerne River, was diverted from the old channel at Corinth and initiated the present Hudson valley from Corinth eastward."

Submerged fjord outlets have been observed in the Gulf of Maine, the Gulf of St. Lawrence, and Hudson Bay, at depths of 2264, 3666, and 2040 feet, rerespectively. Equally striking submarine valleys have been observed on the Pacific coast. Just outside of the delta of the Mississippi River a submarine valley 3000 feet in depth has been located by the United States Coast Survey. Similar drowned valleys are known in other parts of the country.

An elevation of 2000 feet would raise the basins of the Great Lakes sufficiently to provide the necessary grade for such a large river system. Spencer's[4] map shows a large stream, called the Laurentian River, which has its head waters in the northern basin of Lake Michigan, flows thru a portion of Lake Huron and Georgian Bay, thence to Lake Ontario by way of a buried channel passing just west of Lake Simcoe and between Newmarket and Richmond Hill; thru the basin of Lake Ontario it flows eastward at the base of a submerged escarpment, and near the east end of the Lake Ontario basin it bends to the northeast and enters the St. Lawrence Valley near Kingston. Two tributaries join the main river in the Huron basin, one, the Huronian River, flows thru Saginaw Bay and another, unnamed, flows from the St. Clair River northward.

A large river system, known as the Erigan River, flows thru the shallow Erie basin and joins the Laurentian River in the Ontario basin by a buried

[2] Warren Upham, Amer. Journ. Sci., (iii), XLI, p. 36, *et seq.* Spencer states that this elevation may have been as much as 9,000 feet.

[2a] Glacial Geology of the Saratoga Quadrangle. Bull. N. Y. State Museum, No. 183, p. 31.

[3] Amer. Journ. Sci., (iv), XIX, pp. 1-15, 1905.

[4] Falls of Niagara.

channel cut thru the Niagara peninsula about fifteen miles west of the present Niagara River. This main channel has several buried tributary channels, one of which is in the form of a crescent and connects with the Whirlpool canyon of the present Niagara gorge and with the drift-filled Whirlpool-St. David Valley. Other buried river valleys occur at Port Stanley and Victoria in the Erie basin and at Dundas and Hamilton in the west end of the Ontario basin. Lakes Seneca and Cayuga[5] are believed to be ancient river valleys cut in the bed rock and connected with the Laurentian River by buried channels. At Cleveland a preglacial channel has been found in the Cuyahoga Valley, and the ancient river has been christened the Newberry.

Ortmann[6a] believes that the north and south portions of the United States were separated by a divide consisting of the Allegheny Mountains and the Cumberland Plateau, which are thought to have joined the Ozarks and the high western plains in front of the Rocky Mountains. North of this divide the drainage was into the old St. Lawrence system and south of the divide the drainage was into the Atlantic and the Gulf of Mexico. The Tennessee and Cumberland rivers are thot to be the old headwaters of the Lower Mississippi River in preglacial times. The ice sheet is believed to have dammed up the rivers, forming lakes, and the Upper Mississippi system cut through the divide between the Ozark Mountains and the Cumberland Plateau. The present distribution of the fresh water mussels and the crawfishes suggest such a preglacial and postglacial history, these groups of animals being strongly affected in their distribution by the glacial changes.

b. ANCIENT RIVERS WITH REVERSED OR ALTERED MODERN DRAINAGE

Several modern rivers are made up in part of the reversed tributaries of this ancient Laurentian River.[6] The upper Allegheny has been shown to be the upper portion of an ancient river which flowed northward and entered the Erie basin east of Dunkirk, New York(Carll River). The upper Ohio, including the Monongahela and the lower Allegheny, also flowed northward thru the Grand River and entered the Erie Valley. This old stream has been named the Spencer River.[7] The Genesee River is a preglacial stream (one of the few retaining the preglacial northward direction of flow) which has been forced by the drift deposits to cut a new canyon-like channel at Portage and Rochester. Irondequoit Bay is believed to be the outlet of the preglacial Genesee River.[8]

In Ohio, Indiana, and Illinois, ancient, now buried, river channels have been discovered by means of well borings. In Ohio a wide area has been studied

[5] Tarr, Bull. Geol. Soc. Amer., V, pp. 339-356.

[6] Chamberlin and Leverett, Amer. Journ. Sci., (iii), XLVII, pp. 247-283, 1894.

[6a] Topog. Geol. Surv. Penn., 1910, 1912, Appendix E, p. 138, 1912.

[7] Forshay, Amer. Jour. Sci., (iii), XL, pp. 397-403, 1890.

[8] Fairchild, Proc. Roch. Acad. Sci., III, pp. 236-239, 1906; Chadwick, Proc. Roch. Acad. Sci., V, pp. 123-160, 1917.

and many channels have been mapped, indicating the preglacial drainage systems of the Ohio, Muskingum, Great and Little Miami, Mad, Wabash, Vermilion, Black and Rocky rivers, besides numerous smaller streams.[9] These buried valleys indicate changes of channel in many places, the change in some instances being notably marked. Several streams with a present southward drainage are shown to have drained northward in preglacial times. In southern Indiana, the lower Wabash and its tributary rivers, as well as the Ohio River, flowed in preglacial channels which are now drift-filled and the present streams have excavated new channels for the most part.[10] The Ohio River did not exist at that time as a separate stream. Its present channel was occupied by a series of disconnected water courses, varying in size from small ravines to large rivers. Many of the streams in West Virginia and Kentucky flowed northward across Ohio, using the drainage channels now occupied by streams flowing in the opposite direction. Presumably they entered river channels now the site of the Great Lakes and the Wabash River.[11]

In western Illinois a river system composed partly of the present Pecatonica, Rock, and Illinois rivers, has been more or less perfectly worked out by Leverett and other geologists.[12] The drainage was southward and indicates that the Mississippi above the Rock Island rapids turned southeast and joined the southward trunk of the Rock River (in a preglacial channel) near the Town of Ohio, the combined streams forming a large river (the preglacial Illinois) which joined the modern Illinois below Hennepin. Well records made in Iroquois, Champaign, Livingston, and McLean counties indicate that an old valley extends southward from Lake Michigan thru portions of these counties. At Chatsworth, Livingston County, its depth is 200 feet, and at Bloomington the trough is 230 feet deep. Between Onarga and Gilman it is 268 feet and near Spring Creek station it is over 400 feet beneath the surface.[13] Similar buried channels are known in the region bordering the southern shore of Lake Michigan.[14]

In Iowa a number of preglacial river channels have been traced, especially in the southeastern portion of the state, where the Mississippi and tributary streams have been shown to have occupied other and larger valleys in preglacial

[9] Tight, Bownocker, Todd, Fowke, The Preglacial Drainage of Ohio, Special Papers, No. 3, Ohio Acad. Sci., 1900.

[10] Leverett, Illinois Glacial Lobe, plates 8 and 9; pp. 93, 96, 102, etc.

[11] Tight, Professional Papers, U. S. G. S., No. 13. The map, plate 1, indicates the preglacial drainages of these rivers, which are given names. Two of the rivers seem to have been christened already. Thus Tight's Pittsburg River seems to be the same as the Spencer River of Forshay, and the Cuyahoga is the same as the preglacial Newberry River.

[12] Ill. Glacial Lobe, plate 12.

[13] See Geology of Ohio, II, pp. 13-14; Bradley; Geol. Ill., IV, pp. 229-230, 1870.

[14] See Chapter III.

times.[15] Near Des Moines a number of preglacial "cut-outs" have been located while sinking mine shafts. Other buried channels have been found in different parts of the glaciated territory, but they need not be referred to at this time. In southeastern Wisconsin, Alden[15a] has traced a number of preglacial channels buried beneath glacial till, several of these draining into Lake Michigan.

A few years ago,[16] Prof. A. W. Grabau, using the data published by Spencer and other geologists, worked out a theory of preglacial drainage, in which the main or consequent streams are made to flow southwestward, or in a transverse direction to the Niagara cuesta. Four streams are postulated; (1) a stream flowing thru the narrow straits of Mackinac into the Lake Michigan basin; (2) a large stream, the Saginaw River, flowing southwestward thru Georgian Bay and Lake Huron; (3) a large river, the Dundas, flowing from the highlands of Canada thru the western end of the Ontario basin, thence by the buried Dundas Valley to the Erie basin; and (4) the ancient Genesee River, flowing across the Ontario basin into southern New York. These four major streams are shown by later adjustment (principally piracy) to develop into two large river systems, the Saginaw and the Dundas (Plate LV). The valleys of Cayuga and Seneca lakes are made to contain southward flowing streams and the beheaded Genesee flows southward. This theory of Tertiary drainage, while highly ingenious, does not seem to accord with the known data, when surveyed as a whole, as well as does that of Spencer. The indicated direction of the Genesee River is not in accord with the facts as presented by an examination of the territory, nor does Prof. Grabau give sufficient weight to the old valley of Irondequoit Bay which has been shown by Fairchild to be the ancient outlet of the Genesee. The buried channel between the Erie and Ontario basins, which is given such weight by Spencer, is not given sufficient prominence in this theory.

Miller[16a] considers Grabau's interpretation more tenable than Spencer's theory of a preglacial St. Lawrence drainage. The St. Lawrence is said to be almost certainly postglacial in its course at the Thousand Islands as shown by the lack of any real channel, and by the presence of a belt of hard pre-Cambrian rock extending across the river and connecting the Adirondacks with the Canadian pre-Cambrian rocks. This hard rock belt is thot to have formed a preglacial divide until the recent formation of Lake Ontario and the downwarping of the land, which allowed the drainage to pass over the divide for the first time (p. 82). The drainage of the St. Lawrence is believed to have

[15] See Iowa Geol. Surv., III, pp. 239-255, 1895; also Leverett's Ill. Glacial Lobe, pp. 468-469; Keyes, Iowa Geol. Surv., II, pp. 183-185, 292, 346, 1894.

[15a] Professional Papers, U. S. Geol. Surv., 106, pp. 102-128, 1918.

[16] Geol. and Pal. of Niagara Falls and Vicinity, pp. 37-54.

[16a] Bull. N. Y. State Museum, No. 168, pp. 82-86; 96-107, 1913.

be n southwestward into the Mississippi River. A preglacial Rome River is thot to have flowed thru Oneida Lake, and Black River flowed northward into the St. Lawrence. Rivers in the Cayuga, Seneca, and Genesee valleys are believed to have flowed northward into the St. Lawrence River.

Investigations by Leverett[17] and other glaciologists indicate that some preglacial streams, especially in southern Michigan and northeastern Illinois, had a southerly direction and flowed into the Gulf of Mexico. Whatever the direction of the drainage of this region may have been does not materially affect the established fact that the Great Lakes were once river valleys and that they, together with the buried river channels, formed avenues by which the preglacial biota spread over the country.

2. Preglacial Life of the Glaciated Area

In the preceding pages it has been shown that previous to the advent of the Glacial Period, the physiography of the country was quite mature and that large river systems occupied extensive river valleys. If the physical features were of such maturity, it follows, obviously, that the biota was equally mature. Unfortunately the data bearing upon this point is of the most meagre character, as only a very small portion of the surface was left intact by the first ice invasion, and the diversity of the biota can be judged only by the life contained in deposits laid down beyond the limits of glaciation or in the first interglacial deposits of the Aftonian stage.

Among the mammals the sloths, *Megalonyx*, *Mylodon*, and *Megatherium*, several species of the horse, *Equus*, members of the cat and dog families, the hornless rhinoceros, the tapir, the peccary, numerous species of deer, rodents, some of gigantic size and the proboscidians, the mastodon and mammoths, roamed over the country in great numbers. Of invertebrates, little is definitely known, tho it is believed that the molluscan fauna differed but little from that of today. The insect fauna is said by Scudder to be composed largely of extinct species.

According to Penhallow,[18] a forest of great denseness extended far into the Arctic regions, consisting of such species as beech, sycamore, tulip tree, oak, sweet gum, walnut, magnolia, and many others. A temperate climate, very much warmer than now and somewhat subtropical, extended to the northern boundary of the United States, as shown by fossil plants about the Arctic regions. An Arctic bog flora must have existed north of this great forest, in polar lands.

Data concerning the life immediately preceding the first glacial invasion are rare and meagre. Some remains of life found in caves not far removed from the border of the ice have been thot to be preglacial, but the exact age

[17] Mich. Acad. Sci., 12th An. Rep., p. 22, 1910.

[18] Trans. Roy. Soc. Can., X, pp. 56-74, 1904.

is quite uncertain; in some instances the time of deposition may have been much later. A few of these supposed preglacial deposits may here be considered.

a. FISH-HOUSE CLAY FLORA AND FAUNA, NEW JERSEY

Many years ago, Prof. E. D. Cope obtained from a deposit at Fish-house, Camden County, a number of fresh-water river mussels (*Unionidæ*), associated with the remains of an extinct horse, which were described by Lea[19] and referred to the Cretaceous horizon. Later,[20] Whitfield fully described and illustrated these species and added two more, considering them as belonging, stratigraphically, near the base of the New Jersey Cretaceous. Prof. Cope[21] and Dr. C. A. White,[22] in later publications, have considered the deposits as of Pliocene or Pleistocene age. Dr. H. A. Pilsbry[23] considers the deposit as "either interglacial or preglacial and a divergence of a part of the species from the most allied forms, as well as the fact that the fauna was an abundant one, composed of large and well-developed individuals, point rather to preglacial than to interglacial conditions."

i. Section of Strata at Fish-house[24]

Well section

1. Top soil	3½ feet	
2. Moulding sand	1½ "	
3. Fine gravel	4 "	
4. Fine clayey sand	4 "	
5. Heavy gravel with large pebbles	1½ "	
6. Black or blue clay	5½ "	*Equus* above shell bed; *Unios* near base of bed; plants thruout bed.
7. Ironstone crust	½ "	
8. Dark sand	2½ "	Cross bedded.
9. Fine light sand	4 "	
10. Dark sand	3 "	
11. Light sand and gravel	3 "	
Height of section	33 feet	

The cross bedded sand stratum under the clay deposit indicates that it was laid down in "a former Delaware River bed, the river at that time flowing in a

[19] Proc. Phil. Acad. Sci., 1868, p. 162.

[20] Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey, pp. 243-252.

[21] Trans. Amer. Phil. Soc., XIV, pp. 249-250, 1869.

[22] 3rd. An. Rep., U. S. G. S., 1883.

[23] Proc. Acad. Nat. Sci. Phil., 1896, pp. 567-570.

[24] Woolman, Geol. Surv. New Jersey, An. Rep., 1896, p. 247.

direction practically parallel to its present course, as shown by the direction of the oblique lamination of the strata. A change of the river's course, such as cutting across the neck of an 'ox-bow,' or some similar shifting, left the former bed at this point a lagoon, similar to the so-called 'sloughs' of the Mississippi River. A lagoon of this nature, while it quickly becomes dammed at the up-stream end, for a time receives a portion of the current in time of high water. In the case under consideration, the layer of red, more or less arenaceous, clay was probably deposited during this period of partial isolation. Further separation of the slough from the stream is effected by the growth of willows and other vegetation upon the alluvial ridge at its head, which rapidly gains in height by the debris collected thereby. The lagoon thus formed is a very favorable station for molluscan and other aquatic life, sedentary animals, or those of weak locomotive powers becoming far more numerous than in the active current of the parent stream. Such a lagoon thus gradually fills up with fine mud partly composed of organic material. In the case under consideration, the black clay represents this period. Finally the lagoon or 'slough' became dry land, this being the ordinary result of the process. The naiad fauna of the Fish-house Deposit is precisely similar in general character to that of the 'sloughs' of the Mississippi River today."[25]

ii Life of the Fish-house Clay

Plants[26]

Coniferous and deciduous wood represented by plant stems and seed.

Birch (*Betula*)	Maple (*Acer*)
Pine (*Pinus*)	Basswood (*Tilia dubia*)
Oak (*Quercus*)	Gum (*Nyssa biflora*)

Animals (Mollusca)[27]

Fish-house species	Alleged allied living forms	Present habitat
Unio subrotundoides Lea	*subrotundus* Lea	Mississippi drainage
" *rectoides* Whitfield	*rectus* Lam.	" "
" *praeanodontoides* Whitfield	*anodontoides* Lea	" "
Anodonta corpulentoides Lea	*corpulenta* Cooper	" "
" *grandioides* Lea	*grandis* Say	Mississippi and St. Lawrence drainage
Unio ligamentoides Lea	*ligamentinus* Lam.	
" *alatoides* Lea	*alatus* Say	
" *humerosoides* Lea	*complanatus* Sol.	Atlantic and St. Lawrence drainage
" *radiatoides* Lea	*radiatus* Lam.	

[25] Pilsbry, *op. cit.*, pp. 568-569.

[26] Woolman, *op. cit.*, p. 211; Berry, Torreya, VII, pp. 80-81; X, pp. 260-261.

[27] Woolman, *op. cit.*, pp. 211, 208. The writer has rearranged the habitats to correspond with the present knowledge. The old nomenclature is used.

Unio nasutoides Lea	*nasutus* Say	Atlantic drainage
" *cariosoides* Lea	*cariosus* Say	" "
" *roanokoides* Lea	*roanokensis* Lea	" "

Vertebrata (Pisces)

Fish scales of undetermined species.

Mammalia

Equus complicatus Leidy.

It will be noted that of the twelve species of mollusks listed, only four resemble the species now living in the Delaware River.[28] Of the balance three are compared with species found in the St. Lawrence and Mississippi River drainages, while four of the compared species are confined exclusively to the Mississippi River and its tributaries. It will also be noted that there is a total absence of the heavy, rounded or tuberculate naiads of the Mississippi and Ohio rivers and this feature of the fauna is believed by Pilsbry to indicate a migration via the Great Lakes region, and thru some river systems in New York, where head waters were near the head waters of the ancient Delaware River. Pilsbry further states that the fauna is "either interglacial or preglacial, and probably the latter." The fact that there is a total lack of trans-Alleghenian species in the present molluscan fauna of the Delaware River points to the great antiquity of the Fish-house fauna, and the presence of the river type of mussels indicates a migration by a river system, which could only have been preglacial as it is believed that subsequent to the Kansan Glacial Epoch, the Great Lakes region has contained a lake rather than a river system. The abundance of the fauna taken in connection with their "divergence from the most allied living forms, point to preglacial rather than interglacial conditions."

Ortmann[29] does not agree with Pilsbry, Lea, and Whitfield in the relationship assigned to these mollusks. He says "But for the present time these fossils are absolutely useless, because western affinities have been maintained for these species, which surely do not exist. The species have been identified mainly from casts, and Lea as well as Whitfield have indicated, by the names given to them, their supposed affinities to western species. I have taken the trouble of making plaster casts of the inside of specimens of the living species with which they have been correlated, and practically in all cases it became evident at a glance that there was no similarity at all.

"But this should be the subject of a special paper. It suffices here to make the statement, first, that the number of species described from this deposit (about a dozen) should be reduced to not more than three or four, and second, that there is not a single one which has distinct and unmistakable affinities to any typical western species."

[28] The four species are *complanatus, nasutus, radiatus, cariosus.*

[29] Proc. Amer. Phil. Soc., LII, p. 280, 1913.

In order that Ortmann's statement might be tested, casts were made of several of the western species (*recta*, *anodontoides*, *ligamentina*, and *alata* as well as the eastern *nasuta* and *radiatus*) and the fact became evident that Ortmann's statement was abundantly borne out by the experiment. The casts bear little or no resemblance to the species with which they are compared. Internal casts are always uncertain objects to accurately identify and it will be difficult to correlate the Fish-house material with modern forms. It seems evident, however, that the fauna does not represent a recent migration from the west, but an indigenous fauna, perhaps of long occupancy, modified by time and related intimately to the present fauna of the Atlantic drainage. Many of the figures published by Whitfield are strongly suggestive of such species as *complanatus quadrilaterus* Lea, *dariensis* Lea, and *jayensis* Lea. All facts at hand indicate that the fauna, while old, was not derived from western stock (except remotely) but was a typical Atlantic coast fauna, living in waters warmer than those of the present Delaware, and related intimately to the species now living in the Carolinas and Georgia.

iii. Age of the Fish-house Clay

Dr. Berry,[30] who has studied the plant remains, places the Fish-house clay flora and fauna in the late Pleistocene; he remarks that "in the judgment of the writer the fossiliferous stratum at least is not older than the last interglacial and the probability is strong though unverified, that it is post-glacial in age."

Recent geological works[31] place the Fish-house beds in the Pensauken stage of the Columbia formation, which is about midway of the Pleistocene series. In the Philadelphia Folio,[32] the following statements occur.

"The Delaware River phase of the Pensauken is composed of debris which is believed to have been brought down by streams from the north during one of the early glacial epochs, an epoch which antedated the last glacial epoch by a very long period of time. The streams, such as the Delaware, leading out from the ice sheet and laden with debris which the ice had prepared, aggraded their valleys, and the ice floating down the streams helped them to transport the large pieces of rock, occasionly of bowlder size, which occur in the formation of this region. The same agency—floating ice—helps to account for the unworn character of some of the coarse material of the formation, and at the same time affords a rational explanation of the presence so far from its source of such soft materials as the friable Newark shale and sandstone. It is not believed that rivers, unaided by floating ice, could have carried them so far, and it is still more incredible that they could have been transported from their original position by waves. Furthermore, a single well-glaciated stone has been found

[30] Torreya, X, pp. 260-262, 1910.

[31] Chamberlin and Salisbury, Geology, III, p. 451.

[32] U. S. Geol. Surv., Atlas, No. 162, p. 14.

in the Pensauken at Falsington, Pa., a few miles north of this district. Material much like the Pensauken occurs up the Delaware as at Raven Rock, at much higher levels (200 feet), seeming to point to the direction whence the material came. At least one distinctly glaciated bowlder has been found at Raven Rock. As already indicated, the material of the tributary valley phase of the formation had a different and more local source."

"The blocking of the minor post-Lafayette channels in later Pleistocene time produced ponded areas in which were laid down the thick deposits of black clay so typically developed at Fish House and at numerous other points toward the south, through New Jersey, Delaware, and Maryland."[33]

Fuller[34] refers the Pensauken to the pre-Kansan (Nebraskan) stage and it seems best, all facts considered, to place the age of these beds, for the present at least, as antedating the first glaciation (Nebraskan or Jerseyan) which, perhaps, was the cause of the extinction of the biota.

b. PORT KENNEDY CAVE FAUNA AND FLORA, PENN.

At Port Kennedy, Montgomery County, Pennsylvania, in a cave containing extensive bone deposits, a large and varied fauna and flora was discovered many years ago. It is believed to be contemporaneous with the Fish-house clay beds.[35] Osborn[36] considers this fauna as early mid-Pleistocene, but with 80 per cent of the mammalian fauna extinct, it would seem to be more logically referred to late Pliocene, as suggested by Hay.[37] The insects are all extinct.[38] In a later paper[39] Hay expresses the opinion that the Port Kennedy fauna is the equivalent of the Aftonian beds of western Iowa. As the question is still unsettled, the biota will here be considered as antedating the first glacial period (Nebraskan or Jerseyan).

The biota of the Port Kennedy deposits contain 13 species of plants and 70 species of animals, as noted below.[40]

Plants

Quercus alba	*Pinus rigida*
" *palustris*	*Carya alba*
" *macrocarpa*	" *porcina*
Fagus ferruginea	*Ampelopsis quinquefolia*
Corylus americana	*Crataegus crus galli?*
Prunus species	" species
	Sphagnum species

[33] *Op. cit.*, p. 19.
[34] Amer. Geol., XXXII, pp. 308-312, 1903.
[35] Woolman, *op. cit.*
[36] Bull. U.S. Geol. Surv., No. 361, p. 84.
[37] Science, N. S., XXX, p. 892, 1909.
[38] Scudder, Amer. Journ. Sci., (iii), XLVIII, p. 181, 1894.
[39] Smith. Mis. Coll., LIX, No. 20, p. 15.
[40] Cope, Journ. Phil. Acad. Sci., XI, pp. 193-289, 1899.

Animals (Insects)

Aphodius praecursor
" *micans*
" *scutellaris*
Phanaeus antiquus
Choeridium ebeninum
Chlaenius punctatissimus
" *punctulatus*
Cymindis aurora
Dicaelus alutaceus
" species
Pterostichus laevigatus
" *longipennis*
Cychrus wheatleyi
" *minor*

Amphibia

Rana species

Reptilia

Clemmys insculpta
" *percrassus*
Terrapane anguillulatus
Bascanion acuminatus

Aves

Meleagris altus
Gallinago species

Mammalia

Erethizon? dorsatus
Sciurus calycinus
Castor canadensis
Zapus hudsonius
Peromyscus, cf, *lucopus*
Anaptogonia hiatidens
Sycium cloacinum
Microtus diluvianus
" *speothen*
" *didelta*
" *involutus*
Lepus sylvaticus
Ochotona palatinus
Osmotherium spelaeum
Mephitis fossidens
" *orthostichus*
" *leptops*
" *obtusatus*
" species
Pelycictis lobulatus
Lutra rhoadsi
Taxidea americana
Machaerodus gracilis
" *mercerii*
Felis inexpectatus
" *eyra*
" *calcaratus*
Mylodon harlani
Megalonyx wheatleyi
" *loxodon*
" *tortulus*
" *scalper*
Blarina simplicidens
Scalops?
Vespertilio species
Arctodus haplodon
Ursus americanus
Canis latidentatus
" *cinereoargentatus*
" *priscolatrans*
Mustela diluviana
Gulo luscus
Mammut americanum
Tapirus haysii
Equus fraternus
" *fraternus pectinatus*
Tayassu tetragonus (=*Mylohyus*)
" *pennsylvanicus*
" *nasutus*
" species
Teleopternus orientalis
Dama laevicornis
" species

c. HAY SPRINGS FAUNA, NEBRASKA

In the northwestern part of Nebraska, at Hay Springs, near the Niobrara River, a plains fauna has been found which is comparable in point of time with the Port-Kennedy biota. The mammals as listed by Matthew are as follows.[41]

Canis latrans
? *Dinocyon* species
Felidae (foot bones of several species)
Fiber zibethicus
Arvicola cf. *amphibius* (=*Microtus*)
Cynomys cf. *ludovicianus*
Thomomys species
Castoroides species
Paramylodon nebrascensis
Equus complicatus
" *fraternus*
Equus? scotti
Elephas columbi
Platygonus vetus
" *compressus*
Leptochaerus species
Camelops kansanus
" *vitakerianus*
Camelus americanus
Antilocapra cf. *americana*
Capromeryx furcifer

d. OTHER FAUNAL AREAS

In Kansas a fauna has been reported by Udden[42] which, judging by the species represented, might be referred to the Aftonian stage. Howarth and Beede,[43] however, do not think that these deposits, which extend thru McPherson, western Marion, Harvey, and eastern Reno counties, are in any way connected with the Kansan ice, the altitude of McPherson County being much higher than that of the nearest Kansan drift. The deposits are in an old river valley (probably preglacial) cut in the underlying bed rock, and the deposits are thot possibly to be the result of a change of drainage at which time a greater volume of water flowed thru the valley. Hay[44] refers the vertebrate remains in the gravel (number I) to the Pliocene, and this is probably the best disposition. The deposits present the following section:

V. Yellow sand
IV. Volcanic dust
III. Clays
II. Sand
I. Gravel
Rock

In the gravel number I the following mammals were found:

Megalonyx leidyi
Equus complicatus

[41] Bull. Amer. Mus. Nat. Hist., XVI, pp. 317-322, 1902; Brown, *op. cit.*, XIX, pp 569-584, 1903.
[42] Amer. Geol., VII, pp. 340-345.
[43] Univ. Geol. Surv. Kansas, II, p. 287.
[44] Bull. 179, U.S. Geol. Surv., p. 578.

In the sand above the gravel a number of mollusks occurred, in the upper part of the deposit.

Anodonta species	*Pisidium abditum*
Sphaerium striatinum	*Valvata tricarinata*
" *simile(=sulcatum)*	

One crustacean, a *Gammarus*, occurred with the shells.

Williston[45] lists the vertebrate fossils of Kansas, referring them to the late Pleistocene (Champlain stage). In view of the modern conception of the complexity of the Glacial Period, and in view, also, of the high percentage of extinct species recorded, the fauna would seem to be referable to preglacial time, or late Pliocene. As Williston remarks, however, all of the material may not be contemporaneous in time. The species listed (excepting *Homo sapiens*) are as follows.

Mammut americanum(=giganteum)	*Equus complicatus*
Elephas primigenius	" *curvidens*
" *imperator?*	*Platygonus compressus*
Bison americanum (?)	*Camelops kansanus*
" *antiquus*	*Auchenia huerfanensis*
" *crampianus*	*Camelids*, species indet.
" *alleni*	*Megalonyx leidyi*
Alces species	*Mylodon?* species
Equus major	*Canis lupus*
" *excelsus*	" species
" *occidentalis*	*Geomys bursarius*

The Nebraskan drift frequently contains wood which it has picked up as it has overridden a preglacial forest. Such are recorded from Louisa County,[46] and Jefferson County,[47] Iowa.

Interesting deposits of Pleistocene animals, as well as plants, have been found in caves in Newton Co., Arkansas[47a] (the Conrad fissure) and near Cumberland,[48] Maryland, but these are thot to be of later date than the Port Kennedy and Hay Springs deposits. Hay believes the Conrad fissure fauna to be of Sangamon interglacial age. As these deposits are beyond the limits of the ice-covered territory, the fauna is not here listed.

[45] Univ. Geol. Surv. Kansas, II, pp. 297-308.
[46] Udden, Geol. Iowa, XI, pp. 101-111.
[47] Udden, *op. cit.*, XII, pp. 422-428.
[47a] Mem. Amer. Mus. Nat. Hist., IX, pp. 157-208, 1908.
[48] Proc. U. S. Nat. Mus., XLVI, pp. 93-102, 1913.

3. Catalog of the Preglacial Biota[48a] Referred to in this Chapter

PLANTS

BRYOPHYTA

Sphagnaceae

Sphagnum species

SPERMATOPHYTA

GYMNOSPERMAE

Pinaceae

Pinus rigida

Pinus species

ANGIOSPERMAE

DICOTYLEDONEAE

Juglandaceae

Juglans species

Carya alba(L.) K. Koch
" *glabra* (Mill) Spach.
(=*porcina* Nutt).

Betulaceae

Corylus americana Walt.

Betula species

Fagaceae

Fagus grandifolia Ehrb, (=*ferruginea* Ait)
Quercus alba L.

Quercus macrocarpa Michx.
" *palustris* Meunch.

Magnoliaceae

Magnolia species

Liriodendron tulipifera L.

Hamamelidaceae

Liquidambar straciflua L.

Platanaceae

Platanus occidentalis L.

Rosaceae

Crataegus crusgalli L.
" species

Prunus species

Aceraceae

Acer species

Vitaceae

Psedera quinquefolia (L.) Greene

[48a] This catalog is necessarily very fragmentary and includes some species which may belong to a later period than that assigned. It is believed, however, that it will serve a useful purpose as a basis for comparison with later biota, which are definitely fixed in their relation to certain drift sheets. No tangible evidences of life have as yet been found beneath the Nebraskan drift, and we are compelled, therefore, to rely upon the territory outside the drift area for evidences of preglacial life. Extinct species are marked with an *.

Tiliaceae

Tilia dubia Newberry

Cornaceae

Nyssa sylvatica biflora (Walt.) Sorg.

ANIMALS

MOLLUSCA[49]

Unionidae

Unio subrotundoides Lea
* " *rectoides* Whitfield
* " *praeanodontoides* Whitfield
* " *ligamentoides* Lea
* " *alatoides* Lea
* " *humerosoides* Lea
Unio roanokoides Lea
* " *radiatoides* Lea
* " *nasutoides* Lea
* " *cariosoides* Lea
Anodonta corpulentoides Lea
* " *grandioides* Lea

Sphaeriidae

Sphaerium striatinum (Lam.)
" *simile* (Say) = *sulcatum* Lam.
Pisidium abditum (Hald.)

Valvatidae

Valvata tricarinata (Say)

CRUSTACEA

Gammarus species

INSECTA

COLEOPTERA

Scarabaeidae

Aphodius praecursor Scudder
* " *micans* Scudder
* " *scutellaris* Scudder
Phanaeus antiquus Scudder
Choeridium ebeninum Scudder

Carabidae

Chlaenius punctatissimus Scudder
* " *punctulatus* Scudder
Cymindis aurora Scudder
Dicaelus alutaceus Scudder
* " species
Pterostichus laevigatus Scudder
* " *longipennis* Scudder
Cychrus wheatleyi Scudder
* " *minor* Scudder

VERTEBRATA

PISCES

Scales of fish, undetermined

[49] The species described from the Fish-house clay beds are here listed as recorded by Whitfield. There seems to be no other course open until the original material is carefully compared with Atlantic coast species. They are also here recorded as extinct for the same reason altho probably correlative with living species.

AMPHIBIA

Ranidae

Rana species

REPTILIA

Emydidae

**Clemmys insculpta* LeConte
* " *percrassus* Cope
**Terrapene anguillulata* (Cope)

Colubridae

**Bascanion acuminatus* (Cope)

AVES

Scolopacidae

Galllinago species

Phasianidae

**Meleagris superbus* Cope(=*altus* Cope)

MAMMALIA

Megetheriidae

**Magalonyx wheatleyi* Cope
* " *loxodon* Cope
* " *tortulus* Cope
* " *scalper* Cope.
**Megalonyx leidyi* Lindahl
**Mylodon harlani* Owen
**Paramylodon nebrascensis* Brown

Equidae

**Equus complicatus* Leidy (=*major* Cope)
* " *fraternus* Leidy (=*curvidens* Leidy)
* " *excelsus* Leidy
**Equus occidentalis* Leidy
* " *scotti* Gidley
* " *pectinatus* Cope

Tapiridae

**Tapirus haysii* Leidy

Tayassuidae

**Leptochoerus* species
**Platygonus compressus* LeConte
* " *vetus* Leidy
**Mylohyus pennsylvanicus* (Leidy)
* " *nasutus* (Leidy)
* " *tetragonus* (Cope)

Camelidae

**Camelops kansanus* Leidy
(=*Auchenia huerfanensis* Cope)
* " *vitakerianus* (Cope)
**Camelus americanus* Wort.
**Teleopternus orientalis* Cope

Cervidae

Alces americanus Clinton (?)
**Odocoileus laevicornis* (Cope)
**Capromeryx furcifer* Matthew

Antilocapridae

Antilocapra americana Ord. (?)

BOVIDAE

Bison antiquus Leidy
**Bison alleni* Marsh
= *B. crampianus* Cope

ELEPHANTIDAE

**Mammut americanum* Kerr = *Mastodon giganteus*
**Elephas primigenius* Blumenbach
* " *columbi* Falconer
* " *imperator* Leidy

SCIURIDAE

**Sciurus calycinus* Cope
Cynomys cf. *ludovicianus* (Ord)

CASTORIDAE

Castor canadensis Kuhl.

MURIDAE

Peromyscus leucopus (Raf.)
**Anaptogonia hiatidens* Cope
**Sycium cloacinum* Cope
Fiber zibethicus (Linn.)
**Microtus diluvianus* Cope
* " *speothen* Cope
* " *didelta* Cope
* " *involutus* Cope
* " cf. *amphibius* Cope

GEOMYIDAE

Geomys bursarius (Shaw)
Thomomys species

DIPODIDAE

Zapus hudsonius (Zimm.)

ERETHIZONTIDAE

Erethizon dorsatus (Linn.)

CASTOROIDIDAE

**Castoroides ohioensis* Foster

OCHOTONIDAE

**Ochotona palatinus* (Cope)

LEPORIDAE

Lepus sylvaticus Bachm. (= *Sylvilagus floridanus* (Allen).

TALPIDAE

Scalops? species

SORICIDAE

**Blarina simplicidens* Cope

VESPERTILIONIDAE

Vespertilio species

URSIDAE

Ursus americanus Pallas
**Arctodus haplodon* (Cope

MUSTELIDAE

Taxidea taxus (Schreber) = *T. americana* Bodd.
**Mephitis fossidens* Cope
**Osmotherium spelaeum* Cope
**Pelycictis lobulatus* Cope

**Mephitis orthostichus* Cope	**Mustela diluviana* Cope
* " *obtusatus* Cope	*Gulo luscus* (Linn.)
* " *leptops* Cope	**Lutra rhoadsii* Cope

CANIDAE

Canis latrans Say	**Canis latidentatus* (Cope)
* " *priscolatrans* Cope	" *occidentalis* Rich. (=*lupus*)
* " *cineroargentatus* Schreber	*Dinocyon* species

FELIDAE

**Machairodus gracilis* Cope	**Felis inexpectatus* (Cope)
* " *mercerii* Cope	" *eyra* Desm.
	* " *calcaratus* Cope

4. SUMMARY

Preglacial Condition of the Glaciated Area. Previous to the Glacial Period the region now occupied by the Great Lakes formed an immense river valley comparable to that of the Mississippi, the outlet being possibly by way of the St. Lawrence Valley. The watershed of the country was at this time quite different from that of the present, many streams flowing northward and emptying into the large Laurentian River. The land was also much higher then than now, and many of the rivers (the Hudson, St. Lawrence, and others) extended seaward and formed great canyons which are now deeply buried beneath the ocean.

Preglacial Biota. The life which existed prior to the ice age was different in many respects from that which occupies the same territory today. The plants experienced little or no change. Of the 23 species listed in the previous catalog, but one is doubtfully extinct. The mollusks have probably remained much the same, altho the land forms might contain some extinct races if the record was complete. The fresh water species (with the exception of the problematical casts from the Fish-house clay beds in New Jersey) are identical with living forms. During the long period from the Cretaceous and thru the Tertiary Period the fresh water shells, and especially the naiades, spread over the eastern and southeastern part of the United States, probably by way of the river systems which connected with the preglacial Laurentian River. The 14 species of insects are all extinct.

Of the 86 vertebrates, 64 are extinct, or over 74 percent. Several families, as the sloths, the horses and the camels, are represented by a number of species. These families, as well as the proboscidians, have become entirely extinct, as far as the region under consideration is concerned.

CHAPTER VI

THE GLACIAL OR PLEISTOCENE PERIOD

The warm Pliocene Period was followed by an interval of intense cold during which time nearly the whole of British America and the United States as far south as northern Pennsylvania, southern Ohio, Indiana and Illinois, central Missouri, eastern Nebraska, central South Dakota, nearly the whole of North Dakota and northern Wyoming, Idaho, and Washington, was covered by immense ice fields, embracing altogether an area of approximately 4,000,000 square miles and attaining a thickness of over 5,000 feet[1] (Plate LVI). Formerly the Glacial Period was thot to consist of but a single ice invasion, but it is now known that as many as five well characterized invasions occurred, each separated by an interglacial period of considerable duration.

1. EFFECT OF THE ICE ON THE TOPOGRAPHY

This thick mass of moving ice planed off the hills carrying with it the residuary soil which had formed during the long Mesozoic and Cenozoic interval, ground up and removed much of the underlying rocks and scratched and grooved the surface of the more resistant rocks. The first effect of the presence of this ice sheet was probably the ponding of the many northward flowing streams, the valleys forming vast lakes, the drainage from which caused the formation of new river valleys, which in their turn cut canyons and gorges.

2. EFFECT OF THE ICE ON THE BIOTA

The effect on the life of the glaciated area was marked and to a certain degree cataclysmal. As the ice advanced the winters became long and the summers short, the seasons being marked by fogs and violent storms. The luxuriant vegetation was overridden, the trees being broken and their remains incorporated in the drift with the other debris—soil and rocks. In many places the newly formed ponds covered the forests and thus killed the trees. The biota was not, however, all killed at once. The process was slow, occupying many years. It is probable that the Arctic plants and such north temperate trees as some conifers, oaks, ash, and a few others, kept possession of the territory in front of the ice, much as do the same genera at the present time in high latitudes. The temperate species migrated, by seed, to points far

[1] The thickness of the ice has been variously estimated at from 3 to 8 miles. See Chamberlin and Salisbury, Geology, III, p. 357.

enough removed to be beyond the direct influence of the Arctic climate. Many species found refuge in the southern part of the Appalachians where we now have a mixed flora of spruce, arbor vitae, pine, hemlock, etc. South of the Ohio River such deciduous plants as elms, maples, magnolias, walnuts, chestnuts, and hickories found refuge and now flourish in great abundance.

During each successive stage of glaciation the biota was completely obliterated in the englaciated territory, the species which were unable to migrate suffering extinction. Later studies have indicated that during each inter-glacial stage an extensive biota flourished, migrating from the south as the territory became suitable for occupancy. This oscillation of life is thus graphically portrayed by Chamberlin and Salisbury.[2]

"A distinguishing feature of the effects of the ice invasions on the life of the glacial period in northern latitudes was an enforced oscillatory migration in latitude. With every advance of the ice, the whole fauna and flora of the affected region was forced to migrate in front of it, or suffer extinction. The Arctic species immediately adjacent to the ice border crowded upon the sub-arctic forms next south of them, the sub-arctic forms crowded upon the cold-temperate forms, and these in turn upon the warm-temperate types, and so on. It is not unlikely that the limits of the tropical zones even were shifted, and the torrid belt appreciably constricted. With the succeed ng deglaciaion of the inter-glacial stages, a reversed migration followed. Present evidence seems to warrant the belief that five or six such to-and-fro migrations were experienced in America and Europe, and that the southward and northward swing of these movements was several hundred miles in extent, in some cases perhaps one to two thousand miles. Some of the inter-glacial epochs saw a northward extension of mild-temperate forms greater than that of today, from which it is inferred that the inter-glacial climates were milder than the present, and hence that the ice-sheets were at least as much reduced as now. There is in this also ground for the inference that the northern tracts were at least as extensively peopled by plants and animals as they are today. This carries the conclusion that the migratory swing in these more pronounced cases was at least 2,000 miles in North America, and more than 1,000 miles in Europe. As indicated in the physical description, the geological evidences drawn from erosion, weathering, and organic accumulation warrant the belief that the inter-glacial intervals were long enough to permit a complete northern return, and the fossil evidence supports the conclusion that the climates were congenial enough to invite it.

"The forced migrations must, in their nature, have been peculiarly effective in bringing to bear a severe struggle for existence, and in calling into play the full resources of the plastic adaptation of the life. Forms previously specialized to meet local conditions were put to a most adverse test, for the invading ice

[2] Geology, III, p. 485.

forced every form within the glaciated area to move on, while the fringing zones of depressed temperature encircling each ice-sheet forced plant and animal life, even beyond the ice border, to seek new fields and new relations, both physical and organic. An incidental result of this wholesale migration was an unwonted commingling of plants and animals, for every aggressive form pushed forward in the van of the advancing zone, and hence came into new organic environment, while every laggard form fell behind and was overtaken by the less reluctant migrants."

Professor Osborn[2a] does not believe that the biota was greatly affected by the ice sheets, at least until toward the latter half of the Glacial Period. He says: "Until the close of Third Interglacial time no traces of northern, much less of Arctic forests and animals, are discovered anywhere, except along the borders of the ice-fields. It would appear as if the animal and plant life of Europe were, in the main, but slightly affected by the first three glaciations. We cannot entertain for a moment the belief that in glacial times all the warm flora and fauna migrated southward and then returned, because there is not a shred of evidence for this theory. It is far more in accord with the known facts to believe that all the southern and eastern forms of life had become very hardy, for we know how readily animals now living in the warm earth belts are acclimatized to northern conditions."

The facts, in America at least, seem to indicate a mingling of Arctic, subaractic, and temperate types of animals south of the border of the ice sheets, and a migration northward during each interglacial interval. In another place (p. 241) Osborn says, "As a result of favorable interglacial conditions arboreal vegetation flourished to the far north along the Arctic Ocean, and the present tundra regions of Siberia and British America then supported forests which have long since been extirpated, the northern limit of similar living trees now lying far to the south." There is apparently no reason why this condition may not have prevailed during the first two interglacial intervals—the Aftonian and Yarmouth.

At the maximum extension of the ice sheet, the biota of the upper Mississippi Valley was concentrated along the southern border of the ice, in Kansas, Iowa, Illinois, Kentucky, Ohio, and Pennsylvania. The aquatic biota was massed in the lower Mississippi and Ohio rivers and in tributary streams. There were five areas from which the biota could repeople the wasted territory left bare by the retreating ice sheet (Plate LVI). (1), that part of the United States lying south of Illinois and Ohio, west of the Allegheny Mountains, and of the Missouri River Valley, and east of the Rocky Mountains, including the lower drainage area of the Mississippi Valley and the adjacent prairies and plains; (2), an area south of British Columbia and Assiniboia, including Montana, Idaho, and Washington, and embracing the upper drainage areas of the Missouri

[2a] Men of the Old Stone Age, p. 108, 1916.

and Columbia rivers; (3), the whole of northern and western Alaska, embracing the Yukon River Valley, besides other smaller streams; and (4), the driftless area in southern Wisconsin bordering the Mississippi River. A fifth region of survival was provided in New Jersey and Pennsylvania east of the Appalachian chain and south of New York.[3]

3. THE ICE INVASIONS

Five distinct ice invasions, separated by four well-marked interglacial intervals are now known, with a possible sixth invasion and a fifth interval. For many years the Glacial Period was thot to be a unit, the complexity of the margin being attributed to minor fluctuations in the ice sheet. Accumulated evidence first noticed in the west by Chamberlin, McGee, Salisbury and other geologists, and more recently recognized in the east by later investigators, have conclusively demonstrated the complexity of the Glacial Period and have established beyond question the reality and significance of the interglacial intervals, which are now believed to have been, in part at least, as extensive and far reaching as is the period in which we live.

The six ice invasions and the five interglacial intervals, as they affected America, may be tabulated as follows:[4]

1 Nebraskan and Jerseyan, first recognized invasion.
  a. Aftonian, first interglacial interval
2. Kansan, second glacial invasion.
  b. Yarmouth or Buchanan, second interglacial interval.
3. Illinoian, third glacial invasion.
  c. Sangamon or Toronto, third interglacial interval.
4. Iowan, fourth glacial invasion.
  d. Peorian, fourth interglacial interval.
5. Early Wisconsin, fifth glacial invasion.
  e. Fifth interval of deglaciation (unnamed).
6. Later Wisconsin, sixth glacial invasion.
  f. Glacio-fluviatile sub-stage.
  g. Champlain sub-stage (marine).

The extent of the interval between the earlier and later Wisconsin invasions is not definitely known. No soil horizons referable to this interval are at present known.

a. *Interglacial Life and Conditions*

The data upon which to reconstruct the fauna and flora of the interglacial intervals are necessarily meagre, consisting of scattered records of imperfectly

[3] There is reason to believe that favorable conditions for the survival of many boreal mollusks existed in Greenland, Newfoundland, Anticosti and other places along the Atlantic coast and also along the Pacific coast (*vide* Scharff, 1907, and Adams, 1905).

[4] Chamberlin and Salisbury, Geology, III, p. 383. The table has been reversed. The name Nebraskan of Shimek replaces the old Sub-Aftonian. Whether this is to be correlated with the Jerseyan of the east is not at present decided.

preserved material. It is obvious that but a small percentage of the remains of the biota could by any possibility be preserved during the invasion and occupancy of a gigantic ice field, such as is known to have covered the englaciated region. It is likewise evident that the greatest care is necessary in using this data, in order that errors may be eliminated; and only that information can be used that is known beyond reasonable doubt to be referable to the particular interval discussed. There are many records that cannot be admitted because of lack of precise geologic data. In many cases it is difficult to determine whether certain deposits are to be correlated with the till sheet (Kansan, Iowan, etc.) upon which they rest, or are the product of much later geologic influences. Likewise, it is practically impossible to correlate the deposits beyond the englaciated territory with those within this area. It is evident, therefore, that only that datum is available which lies in or between the drift material deposited by the great continental ice sheets.

b. *Imbrication of Drift Sheets*

Fortunately, the different drift sheets are imbricated and we are thus able to study their physical characteristics, and to trace one drift sheet until it disappears beneath that of a later period. Beneath the later drift sheets, the

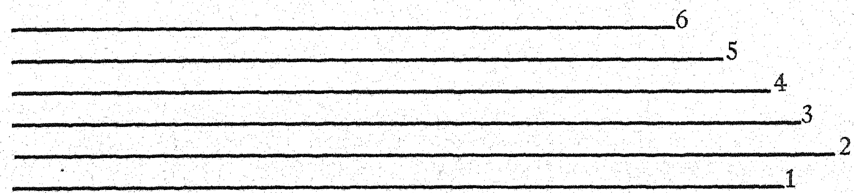

Figure 4. Diagram to illustrate superposition and imbrication of drift sheets (After Chamberlin and Salisbury).

earlier deposits are largely discontinuous and in many places, especially beneath the later Wisconsin drift, are practically absent. The five drift sheets are superimposed as shown in the annexed diagram[5] (figure 4). "Theoretically and perhaps really, the several sheets of drift are imbricated as shown in the figure, but each sheet of drift is discontinuous beneath the overlying one, and this discontinuity goes so far that beneath the Wisconsin drift, for example, the several sheets are more commonly wanting than present." It is to be noted that the earlier, or Nebraskan drift sheet, does not extend beyond the limits of the next younger, or Kansan, and the limit of glaciation of this period is believed to have been considerably less than that which followed. In New Jersey, an old drift, the Jerseyan, extends beyond the limits of the later drift and is believed to be the equivalent of the Nebraskan.[6]

[5] Chamberlin and Salisbury, Geology, III, page 394.
[6] Chamberlin and Salisbury, Geology, III, p. 384.

c. *Age of the Drift Sheets*

The proofs of the great age of the earlier drift sheets are found in the great depth of erosion and the amount of leaching or oxidizing (weathering) that took place before the later sheets were laid down. The intercalated forest beds and old soils also provide criteria of value and the fauna is now proving a criterion of large importance.

d. *Centers of Ice Accumulation and Radiation*

In the central and eastern part of North America there were two centers of ice accumulation from which the glaciers moved outward in all directions. (1) the Keewatin, west of Hudson Bay, and (2) the plains of Labrador. From the first came the ice sheets known as the Nebraskan, Kansan, and Iowan; from the second came the ice sheets known as the Jerseyan, Illinoian, Earlier and Later Wisconsin. The Jerseyan is correlated doubtfully with the Nebraskan.

e. *Effect of Glaciation on the Englaciated Territory*[7]

"The great and unequal erosion of the ice-sheets, and especially the great and unequal deposition of the drift, produced a profound effect upon the topography of the planer parts of the area affected by glaciation. One of the conspicuous results of this alteration of the topography was the derangement of the drainage. One of the results is seen in the thousands of lakes which affect the surface of the later drift, and to a less extent, the surface of the older. The basins of these lakes or ponds arose in various ways. There are (1) rock basins produced by glacial erosion; (2) basins produced by the obstruction of river valleys by means of the drift; (3) depressions in the surface of the drift itself; and (4) basins produced by a combination of two or more of the foregoing. The third class as above, may be subdivided into depressions in the surface of (a) the terminal moraine, (b) the ground moraine, and (c) stratified drift. Since the stratified drift in which the lakes of this last subclass lie is largely in valleys, it would not be altogether inappropriate to class them with group 2.

"In addition to the lakes and ponds now in existence, there have been others of a more temporary character. Some of them have already become extinct by reason of filling or by the lowering of their outlets since the ice melted; others depended for their existence on the presence of the ice, which often obstructed valleys, giving rise to basins. The ice also developed basins outside of valleys, when the surface slope was favorable.

"Another result is to be seen in the changes in the courses of the streams. In many cases, pre-existing valleys were filled with drift, so that when the ice melted the old channels were obstructed at many points, and surface drainage

[7] Chamberlin and Salisbury, Geology, III, pp. 379-381.

was forced into courses which were partly new. In other cases, the ice, by encroaching on the middle course of the valley, as in the case of the Ohio, forced drainage around its front, and the drainage lines thus established by force, were often held after the ice melted."

These changes in topographic relief produced profound changes in the habitats of the fauna and flora. Where previously were rivers and their tributaries, now were ponds, lakes, and swamps (Plate LVII, figures 1, 2). Many fresh water species, upon re-entering the glaciated territory, were compelled to change their normal habitats from river to pond, lake, or swamp. It is probably this change in ecological relationship that has so greatly increased (apparently) the number of species of certain fluviatile animals within the englaciated territory (the fresh water mollusks for example).

It is believed that the old drainage basins of the Laurentian River have been occupied by lakes since an early invasion, perhaps since the Nebraskan and Jerseyan, as old shore lines and biota are known from several interglacial periods.

f. *Length of Time since the Earliest Ice Invasion*

The length of time which has elapsed since the beginning of the Glacial Period and especially the time involved in each interglacial stage is of considerable value in estimating the changes which have taken place in the biota during this long period. McGee[8] thus graphically portrays this time element: "Let the period of written history be represented by a day; then a month or a year of such days will measure the period that has elapsed since the first Pleistocene ice sheet invaded northwestern Iowa. The uncertainty as to the date of the invasion is great; but it was so long ago that the date would be but vaguely conceived if it were possible to write it."

Chamberlin and Salisbury,[9] collating the judgment of five of the glacial geologists who have most studied the available data, give the following table: "The time datum for each sheet of till is the stage at which it began to suffer erosion, which, of course, would be slightly after the beginning of the ice retreat. The time-unit is the period which has elapsed since the Late Wisconsin began to be exposed for erosion:

From the Late Wisconsin to the present	1	time unit	
From the Early Wisconsin to the present	2 to $2\frac{1}{2}$	time	units
From the Iowan to the present	3 to 5	"	"
From the Illinoian to the present	7 to 9	"	"
From the Kansan to the present	15 to 17	"	"
From the Nebraskan to the present	x	"	"

[8] 11th An. Rep., U. S. Geol. Surv., p. 567.

[9] Geology, III, p. 414.

Based upon the time which has elapsed since the cutting of the Niagara gorge (that which is not preglacial) and the Falls of St. Anthony in the Mississippi River, the time limit may be expressed in years as follows:[10]

Climax of Late Wisconsin	20,000	to	60,000	years	ago
Climax of Early Wisconsin	40,000	to	150,000	"	"
Climax of Iowan	60,000	to	300,000	"	"
Climax of Illinoian	140,000	to	540,000	"	"
Climax of Kansan	300,000	to	1,020,000	"	"
Climax of Nebraskan	y	to	z	"	"

These figures are only approximate at best and perhaps possess but little scientific value, but they serve to indicate that a great period of time has elapsed since the beginning of the last ice age, a period long enough for faunas and floras to wax and wane and for many groups to become extinct. The extent of these changes in some groups of animals and the lack of such changes in other groups appear in the pages which follow.

4. SUMMARY

The Pleistocene Period was followed by an interval of intense cold during which British America and the northeastern portion of the United States was successively covered by five or six huge ice sheets. The maximum area covered was 4,000,000 square miles and the thickness is estimated at from 3 to 8 miles. The ice invasions completely changed the topography, replacing the old rivers and streams by ponds, lakes, and swamps. All life was exterminated within the englaciated area, or driven south of it. At each successive interglacial period (of which there were four and possibly five) the biota followed the retreating ice and again occupied the devastated territory, only to be again driven southward by a return of the ice. After the last ice invasion (the Wisconsin) the aquatic life followed the waterways from the melting ice and spread over the territory that we see today. The terrestrial life followed closely the margin of the ice, Arctic, Subarctic, Cold Temperate, and Temperate biota occupying the area in turn, as the climate became suited to each.

The different ice sheets are imbricated at their edges and the drift, as well as the interglacial deposits, may be traced beneath the material of a later drift sheet. The criteria upon which to build an interglacial biota is very fragmentary, and must be selected with care to avoid serious errors, only material from a known geologic horizon being available for use. For this reason deposits outside of the area as well as much material lying upon the drift sheets cannot be used. It is believed that upwards of a million years have elapsed since the first field of ice covered the country, a period of sufficient length to permit great changes in the species of plants and animals inhabiting this region.

[10] Chamberlin and Salisbury, Geology, III, pp. 415-420.

CHAPTER VII

THE NEBRASKAN ICE INVASION AND THE AFTONIAN INTERGLACIAL INTERVAL

I. The Nebraskan Ice Invasion

The extent of the Nebraskan invasion is not positively known, as it fell short of the later Kansan invasion and is buried beneath the drift sheet of this stage. It has been recognized in many places in Iowa and Nebraska and is correlated with early drift deposits in Pennsylvania and New Jersey (Jerseyan). Between these two areas few deposits referable to this stage are known. The ice radiated from the Keewatin center of accumulation and apparently extended down the Missouri Valley to an unknown extent.

The Nebraskan drift is described as "a dark blue-black joint clay, sometimes more or less ferruginous, which when dry is hard and brittle, and breaks up into very small angular blocks (resembling lumps of ordinary starch, as has been suggested). It is almost impervious to water, and when wet is very tough, tenaceous, 'rubber-like,' and so difficult to work that it is the abomination of well-diggers and road-workers, being the despised of all 'gumbos.' "[1] The clay contains a few usually dark colored pebbles and small boulders, many of which are angular and exhibit planed and striated faces, indicating that the Nebraskan is a true drift sheet. Prof. Upham[2] believes that the Nebraskan ice invasion occurred in the latter part of the Lafayette formation, following the Ozarkian epeirogenic uplift.

II. The Aftonian Interglacial Stage

Resting upon the Nebraskan drift are deposits of gravel, sand, and fine silt "variously interbedded and cross-bedded, and evidently deposited by currents of different velocities." The gravel is variously disposed, being at the bottom in one place, at the top in another, and in a few sections it is irregularly interbedded with the sand (Shimek).

A. Organic Remains

The biota of the Aftonian Interglacial stage has been carefully investigated and described by Prof. B. Shimek,[3] whose data form the basis for the discussion

[1] Shimek, Geol. Iowa, XX, p. 307.

[2] Amer. Geol., XXX, pp. 135-150, 1902.

[3] Geol. Iowa, XX, pp. 271-486. The name Aftonian was first used by Dr. Chamberlin in Geike's "Great Ice Age," 1894, pp. 773-774; and in the Journal of Geology, III, p. 272, 1895.

of the life of this stage. Other records of life from the surrounding territory are correlated with this stage, and it is believed that a biota large and varied enough for comparison with earlier and later stages is now available.

a. TYPICAL EXPOSURES OF DEPOSITS

The most typical exposure of Aftonian gravel and sand occurs between Afton and Thayer in Union County, Iowa,[4] where the deposits lie below Kansan drift. Sections nearby show the Nebraskan resting on bed rock. No organic remains were found here, but in Harrison and Monona Counties, evidences of life are found in abundance. A typical section is given by Shimek as follows:[5]

5. Loess, appearing above the cut, and ascending to top of bluff	
4. Loveland, a reddish joint clay, with lines of very large calcareous nodules, more than	15 feet
3. Kansan, typical bluish, very calcareous till	12 "
2. Aftonian:	
Fine whitish silt, about	15 "
Fine silt, mixed with sand, shell bearing	5 "
Coarse gravel, very ferruginous, about	7 "
This reaches 10 feet in the northernmost cut	
Fine cross-bedded sand	6 to 12 "
1. Nebraskan drift, exposed 10 feet, but running out both ways	

The cuts in which these sections are shown form an almost continuous section over 500 feet in length; it is 25 feet above the Little Sioux River, about half a mile south of the county line between Harrison and Monona counties.

b. TYPICAL AFTONIAN FAUNA

The typical Aftonian fauna as described by Shimek[6] and Calvin[7] is as follows:

MOLLUSCA

Aquatic species

Quadrula metanevra	*Ancylus rivularis*
Lampsilis anodontoides	*Galba reflexa*
Sphaerium sulcatum	" *caperata*
Pisidium abditum	" *humilis modicella*
" *compressum*	*Physa integra?*
Amnicola species	*Planorbis antrosus* (=*bicarinatus*)
" *emarginata*	*parvus*
Valvata tricarinata	*dilatatus*
" *bicarinata*	*Segmentina armigera*

[4] Bain, Proc. Iowa Acad. Sci., V, pp. 86-101, 1897.

[5] Geol. Iowa, XX, p. 338.

[6] *Op. cit.*, pp. 316-342; Hay, Iowa Geol. Surv., XXIII. The vertebrate names have been made to conform to this work.

[7] Bull. Geol. Soc. Amer., XX, pp. 341-356; XXII, pp. 207-216.

Terrestrial species

Polygyra (fragments)	*Zonitoides arborea*
Pyramidula alternata	*Bifidaria armifera*
" *cronkhitei anthonyi*	*Succinea ovalis*
Vallonia gracilicosta	" *avara*
Vitrea hammonis	" *retusa*

The molluscan remains were found chiefly in the finer sands, showing that they lived in comparatively quiet water. Exceptionally, odd valves of *Sphaerium* and fragments of Unios were found in gravel. The terrestrial mollusks in the above list were swept into the river by floods or winds, as happens today in similar situations in Iowa and other parts of the glaciated territory.

VERTEBRATA

Pisces

Small vertebra of a fish

Mammalia

Mammut americanum	*Camelus* species
" *progenium*	*Camelops kansanus?*
Rhabdobunus mirificus	*Mylohyus? temerarius*
Elephas columbi	*Megalonyx leidyi?*
" *primigenius*	*Mylodon harlani?*
" *imperator*	*Alces shimeki*
Equus laurentius	*Aftonius calvini*
" *complicatus*	*Bison*, cf. *alleni*
" *niobrarensis*	*Castor canadensis*
" *excelsus*	*Castoroides ohioensis*
Neohipparion gratum	*Ursus americanus*

The bones of these animals are for the most part isolated and in some cases fragmentary, and evidently belonged to animals which had died either in a river or had been washed into a river and the bones separated from the body as it decomposed, either lying upon a sand bar or caught in rubbish along the shore. In Harrison and Monona counties the vertebrate (as well as other) remains have been found in sand and gravel pits, of which those listed below are the most noteworthy.

Harrison County	*Monona County*
Cox pit, Missouri Valley	Wilkinson and Griffin wells
Payton gravel pit, Pisgah	Hawthorn pit, Mapleton
McGavern and Robinson pits	Elliott pit, Turin
Sol Smith Lake	McCleary pit
Logan, Rodney, and Woodbine	Castanea

Shimek[8] refers to a somewhat doubtful section in Snyders Hollow, Harrison County, which is characterized at the base by a deposit of interstratified black

[8] Geol. Iowa, XX, pp. 365-366.

manganese dioxide. Indications are that this should be referred to the Aftonian. Shimek remarks that "while the fossil shells from this stratum are somewhat unlike those which were collected in the Aftonian beds, the difference is no greater than that which we might expect in different parts of the same region, especially since no doubt special conditions existed. It is probable that the deposit was formed in a swamp or shallow lake, and both its shores and bottom would produce environment unlike that of the Aftonian streams. The preponderence of terrestrial species is, however, very unusual." The life of this deposit is indicated below:

Polygyra monodon	*Helicodiscus parallelus*
" *multilineata*	*Succinea avara*
" *profunda*	" *ovalis*
Strobilops labyrinthica	" *retusa*
" *virgo*	*Carychium exiguum*
Bifidaria armifera	" *exile*
" *contracta*	*Helicina occulta*
Vitrea hammonis	*Galba caperata*
Euconulus fulvus	" *humilis modicella*
Zonitoides arborea	*Aplexa hypnorum*
" *minuscula*	*Physa gyrina*
Pyramidula alternata	*Planorbis parvus*
" *cronkhitei anthonyi*	*Pisidium abditum*

C. DISTRIBUTION OF THE AFTONIAN BIOTA

There are a number of deposits beyond the limits of Harrison and Monona counties which are referable to this interglacial stage.

1. *Iowa*

Near Oelwein, Fayette County, a fine white sand deposit, overlying a peat bed, occurs in a railway cut, which is referred to the Aftonian stage.[9] The section may be summarized as follows:

5. Iowan drift	0 to 10 feet
4. Buchanan gravel (Yarmouth stage)	0 to 2 "
3. Kansan drift, with remains of wood	3 to 20 "
2. (a) Sand, fine-white, well water worn, often with little silt and clay (Aftonian)	0 to 6 inches
(b) Vegetal layer and soil, 2-4 inches almost pure carbonaceous matter, the rest largely charged with humus. Moss (Hypnum) common in peat layer (Aftonian)	0 to 4 feet
1. Sub-Aftonian (Nebraskan) drift, greenish blue when wet, greenish cast when dry	10 feet exposed

[9] Beyer, Proc. Iowa Acad. Sci., IV, p. 59, 1897.

The peat moss has been identified as follows:[10]

Hypnum (*Harpedium*) *fluitans* L.
" " *revolvens* Swartz
" (*Calliergon*) *richardsoni* Lesq. and James

The wood in the overlying Kansan drift (which is to be correlated with the Aftonian because it was incorporated in that sheet from the underlying soil horizon) is identified as *Larix americana*. Of the mosses, *revolvens* occurs in deep swamps from northern Ohio to Alaska; *richardsoni* has been reported only from British America and the coast of Greenland. It is thot by Savage, therefore, that the climate in which these plants lived was of a more boreal character than today. This is thot to be indicated, also, by the presence of coniferous trees and the apparent absence of deciduous trees. It is probable that the fauna reported by Calvin and Shimek represents the warm-temperate climate and the Oelwein deposit the subarctic or cold-temperate climate, as suggested by Chamberlin.

Another exposure in Dodge Township, Union County, in the bank of a small stream, tributary to the Grand River, gave the following section:[11]

4. Fine-grained, pebbleless soil, dark gray in color at the surface, changing to yellow in deeper portions	2 feet
3. Yellow colored drift bearing numerous pebbles and small boulders, maximum thickness	21 feet
2. Bed made up of alternating layers of brown colored vegetable matter and fine grained light gray sand. Greatest exposed thickness	6½ feet
1. Blue colored boulder clay containing numerous pebbles and small boulders of granite, greenstones, quartz and quartzite	10 feet

No. 2 is referable to the Aftonian. At the base of the stratum is a layer of clean, fine-grained sand, light colored, about 4 inches thick. Above this a layer of vegetable matter ¾ inches thick, crowded with branches and fragments of wood. In the upper vegetable layers are leaves, stems and rhizoids of mosses. The rootstocks of ferns, blades of grass-like leaves, fragments of leaves resembling *Populus* and leaves and twigs of cone-bearing trees (*Picea*?) were also found as well as the wing covers (elytra) of beetles. The moss has been identified as

Hypnum nitens (Schreb.) Schimp.
" *fluitans* L.

It is thot that this region was first a land surface, then a shallow pond, during which time the moss (which is aquatic) developed; this was drained or filled up and again became a land surface. This was finally covered by the

[10] Macbride, Proc. Iowa Acad. Sci., IV, pp. 63-66, 1897, Savage, *op. cit.*, XI, p. 108, 1904: Holzinger and Best, The Bryologist, Nov. 1903.

[11] Savage, *op. cit.*, p. 105.

Kansan ice sheet. The vegetation here, as in the section at Oelwein, is of a boreal or at least a cold-temperate character.

In Buchanan County,[12] the Kansan till is filled with fragments of wood, which are particularly abundant in the lower part. This wood has been identified as *Larix americana*, and is referable to the Aftonian Interglacial Stage.

In Dubuque County, Calvin found these drift relics and remarks,[13] "almost as characteristic are the battered, frayed, and splintered fragments of trees which are distributed promiscuously throughout a thickness of many feet in the lower part of the drift sheet." In Tama County, Savage[14] records the following section, in Otter Creek Township:

4. Dark-colored soil (loess)	4 feet
3. Yellow clay with boulders (Kansan)	95 feet
2. Blue clay with boulders (Kansan)	260 "
1. Bed of sand containing numerous pieces of wood 2-3 feet in length, 1 inch in diameter, as well as molluscan shells	12 "
Hard rock	x "

Another section in Toledo Township[15] showed an Aftonian deposit containing wood and vegetable remains between Kansan and Nebraskan drift sheets. The mollusks in the above section have not been identified. From a well 20 feet deep, two miles east of Akron, Plymouth County,[16] the bones of *Mammut mirificum* (now *Rhabdobunus mirificus*) have been taken; and at Le Mars (same county) a pelvis was secured which probably belongs to the same species. Possibly the tusk found in Grimes pit, at a depth of 40 ft., may be referred to the same horizon (Hay, p. 389). The foot bones of a *Megalonyx* were also found in the Jensen well, near Akron. From near Afton Junction a species of *Hipparion*[17] (now identified by Hay as *Neohipparion gratum*) was secured. Near Council Bluffs[17] (Henton Station) *Camelops kansanus*?, *Equus laurentius*, *E. complicatus*, and *Elephas columbi* have been observed. At Sioux City, Woodbury County, the remains of *Megalonyx* have been found[18] and also *Equus major* (=*complicatus*) which Todd[19] records from sand beneath the upper (Kansan) till. Hay[17] also finds *Equus laurentius* from this locality, and records *Mylohyus*? *temerarius*[17] from the Anderson gravel pit, at North Riverside, near Sioux City (page 227). In Mills County, in sand below drift, a claw phalange of *Megalonyx* was observed by Todd. *Equus complicatus* is also reported from Lyons Township.

[12] Calvin, Geol. Iowa, VIII, pp. 240-241, 1898.
[13] An. Rep. Iowa Geol. Surv., X, pp. 463-470.
[14] Geol. Surv. Iowa, XIII, p. 234.
[15] *Op. cit.*, pp. 231-232.
[16] Calvin, Bull. Geol. Soc. Amer., XX, pp. 355-356.
[17] Bull. Geol. Soc. Amer., XXII, p. 211, Hay, Iowa Geol. Surv., XXIII, p. 149.
[18] Bull. Geol. Soc. Amer., XXII, p. 215.
[19] Proc. Iowa Acad. Sci., VI, p. 126.

In Washington County, a well section disclosed wood and cones of black spruce (*Abies nigra=mariana*) at a depth of 115 feet.[20] Five miles east of Iowa City, Johnson County,[21] a peat bed occurs at a depth of 28 feet, which contains grass, wood and twigs, seeds and other plant remains, besides coleopterous insects.

In Linn County,[22] deep wells have indicated the presence of Aftonian deposits beneath Kansan and Iowan tills. A well section in Township 86 N. R. VI W., 180 feet above the flood plain of the Wapsipinicon River revealed the strata indicated below.[23]

7. Black soil	6 feet
6. Yellow clay, almost clear grit (Iowan loess)	20 "
5. Blue clay, pebbly (Iowan drift)	38 "
4. Clay, yellow, mixed with sand (Yarmouth)	5 "
3. Blue clay, with a few feet of muck (Kansan)	152 "
2. Whitish clay (Aftonian)	2 "
1. Lime rock	1 "
Height of section	224 "

A section near Central City, believed to be in an old channel of the Wapsipinicon River, gave a better showing of Aftonian.[24]

7. Black soil	4 feet
6. Yellow clay, pebbly (Iowan drift)	15 "
5. Yellow sand (Yarmouth)	4 "
4. Blue clay, changeable from hard to soft every few feet (Kansan)	190 "
3. Sand, fine white (Aftonian)	13 "
2. Sand, coarse, with wood (Aftonian)	12 "
1. Coarse gravel (Aftonian)	3 "
Height of section	237 "

Similar sections have been noted in other parts of the county.

A very deep section of Pleistocene strata occurs at Stanwood, in an ancient (preglacial) river valley, in Cedar County.[25] This is indicated below:

9. Yellow clay (Iowan loess)	20 feet
8. Blue muck, ashen (Kansan loess)	7 "
7. Green, bright hard clay	1 "
6. Yellow clay (Loveland)	7 "

[20] Bain, Geol. Iowa, V, pp. 153-154.
[21] Webster, Amer. Nat., XXII, pp. 414-415.
[22] Norton, Geol. Iowa, IV, pp. 168-184.
[23] *Op. cit.*, p. 179.
[24] *Op. cit.*, p. 175.
[25] Norton, Geol. Iowa, XI, p. 344.

5. Blue clay, pebbly (Kansan)	65 feet
4. Sand with fragments of wood, 5 feet very fine, coarser below (Aftonian)	15 "
3. Blue clay, hard, pebbly (Nebraskan)	65 "
2. Sand	116 "
1. Clay, black, hard, tough, dries like shale (Maquoketa shale)	44 "
Height of section	340 "

In Henry County, on the poor farm at Mt. Pleasant, the bones of a mastodon were found in a well, either in or immediately below the Kansan drift.[26] In Page County, near Blanchard, the bones of a mastodon were found in a well 54 feet below the surface and pieces of wood at 90-95 feet (vide Calvin and White). An old soil beneath Kansan drift has been recorded from the following localities, but no definite species of plants or animals are mentioned. Decatur,[27] Benton,[28] Poweshiek,[29] Wayne,[30] Iowa,[31] Chickasaw,[32] Monroe,[33] Mitchell,[34] Kossuth, Hancock, and Winnebago,[35] Cherokee and Buena Vista,[36] Clay and Obrien,[37] Henry,[38] Howard,[39] Cedar,[40] Worth,[41] Dubuque,[42] Plymouth,[43] Delaware,[44] Johnson,[45] Marshall,[46] Guthrie,[47] Pottawattamie,[48] Mills,[49] Fremont,[50] Lyon and Sioux,[51] and Wapello counties.[52]

[26] Anderson, Augustana Lib. Pub., No. 5, p. 27.
[27] Bain, Geol. Iowa, VIII, p. 286.
[28] Savage, Geol. Iowa, XV, p. 201.
[29] Stookey, Geol. Iowa, XX, p. 260.
[30] Arey, Geol. Iowa, XX, p. 224.
[31] Stookey, Geol. Iowa, XX, p. 172.
[32] Calvin, Geol. Iowa, XII, p. 279.
[33] Beyer, Geol. Iowa, XII, p. 379.
[34] Calvin, Geol. Iowa, XII, p. 326.
[35] Macbride, Geol. Iowa, XII, p. 100.
[36] Macbride, Geol. Iowa, XII, p. 317.
[37] Macbride, Geol. Iowa, XI, p. 483.
[38] Savage, Geol. Iowa, XII, p. 289.
[39] Calvin, Geol. Iowa, XII, p. 62.
[40] Norton, Geol. Iowa, XI, p. 343.
[41] Beyer, Geol. Iowa, X, p. 357.
[42] Calvin and Bain, Geol. Iowa, X, p. 463.
[43] Bain, Geol. Iowa, VIII, p. 340.
[44] Calvin, Geol. Iowa, VIII, p. 164.
[45] Calvin, Geol. Iowa, VII, p. 84.
[46] Beyer, Geol. Iowa, VII, p. 230.
[47] Bain, Geol. Iowa, VII, p. 468.
[48] Udden, Geol. Iowa, XVII, p. 496.
[49] Calvin, Bull. Geol. Soc. Amer., XX, p. 344.
[50] Udden, Geol. Iowa, XII, pp. 165-167.
[51] Wilder, Geol. Iowa, X, p. 124.
[52] Shimek, Geol. Iowa, XX, p. 307.

Hay (Iowa Geol. Surv., XXIII) adds the following data concerning the vertebrate fauna of Iowa:

Lee County, Montrose. Tooth of *Equus niobrarensis* at depth of 25 feet (p. 77).

Pottawattamie County, near Oakland. Incisor tooth of *Castoroides ohioensis* from sand in Nishnabotna River (p. 82).

Lyon County, Doon. Tusks of proboscidian in gravels, 25 feet below the surface (p. 83).

Mahaska County, near Oskaloosa. Right innominate bone of proboscidian, brot from bed of Skunk River by hook of fisherman (page 440), possibly Aftonian.

Leighton[52a] records Aftonian wood fragments in a soil zone beneath Kansan till, in new cuts on the C. M. & St. P. Ry., in the vicinity of Delmar Junction.

2. *Nebraska*

In Nebraska, the Aftonian stage has been identified in Douglas County, good exposures occurring at Omaha, where *Equus* and *Elephas imperator* have been found, as well as at Council Bluffs, just across the river.[53] In a cut near Hartington, Cedar County,[54] the Kansan drift rests upon a calcareous marl from which the following mollusks have been identified:

Valvata tricarinata	*Planorbis parvus*
Galba obrussa (=*desidiosa*)	*Succinea obliqua* (=*ovalis*)
" *palustris* (imperfect specimen)	*Sphaerium striatinum*

Todd also describes a "volcanic ash" stratum beneath drift, five or six miles south of Santee, Knox County. Beneath this stratum is a bed of laminated clay containing a multitude of the shells of *Limnophysa desidiosa* (=*Galba obrussa*).[55] Hay (*op. cit.*, page 141) records *Mylodon harlani*? from Tecumseh, Johnson County.

3. *Missouri*

In Missouri, several deposits occur which should apparently be correlated with the Aftonian stage. Three are well within the area covered by the Kansan drift sheet, the balance are near the southern limit of the drift. Bain[56] records a forest bed nine feet in thickness and 120 feet below the surface in Harrison County; McGee[57] mentions a forest bed in Macon County; and

[52a] Science, N.S., XLIV, p. 68, 1916.
[53] Shimek, Geol. Iowa, XX, p. 308, XXI, p. 138.
[54] Todd, Bull. 158, U.S. Geol. Surv., p. 73.
[55] *Op. cit.*, p. 70.
[56] Geol. Iowa, VIII, p. 290.
[57] Trans. Acad. Sci. St. Louis, V, pp. 305-336.

Broadhead gives the following section from a well located five miles southwest of Gallatin, Daviess County, near Honey Creek:[58]

1. Soil	1 foot
2. Yellow clay	3 feet
3. White stratum	4 "
4. Joint clay with pebbles and boulders	12 "
5. Blue clay	20 "
6. Hard red sand	1½ "
7. Yellow sand	7 "
8. Blue sand with sticks and leaves	3 "
9. Clay shales	3 "

In No. 5 of the above section, at a depth of 35 feet below the surface, an elm stick and a grapevine were seen. No. 5 is Kansan and the underlying deposits are certainly Aftonian. Several nearby wells (sections 27, 28, 29, and 33) contained wood, one at 40 feet (walnut) and another (pine) at 70 feet.

South of the Missouri River, in the counties bordering the Missouri-Kansas state line, a few records appear referable to the Aftonian stage. Four miles north of Pleasant Hill, Cass County,[59] the skull of a bison (*Bison latifrons*) was found in gravel with decomposing fresh water shells, at a depth of 12 feet, under soil and dark clay. In Bates County,[60] a well at Papinville gave the subjoined section:

Yellowish clay	30 feet 10 inches
Bluish clay	0 " 4 "
Thin sand stratum with tooth of horse	0 " x "
Gravel bed	5 "

The bones and tusks of a mastodon are reported from the banks of the Marias de Cygnes, embedded in similar deposits.[61] In Vernon County, near Nevada,[62] a gravel bed occurred in a well boring, 16 feet below the surface, which contained a walnut log. Four miles north of this well, charred wood and bivalve shells were found at a depth of 19 feet.[63] In Benton County,[64] *Platygonus compressus* (=*Dicotyles costatus*) has been found associated with mastodon remains. Calvin[65] records several species of mammals from Aftonian deposits near Rockport, Atchison County, in the Whitman gravel pit, sect. 22, T. 64, N, R. 41 W.

[58] Geol. Missouri, 1873-74, pp. 313-314.
[59] Broadhead, Amer. Nat., IV, pp. 61- 62.
[60] *Op. cit.*, pp. 60-61.
[61] Broadhead, Geol. Missouri, 1873-74, p. 157.
[62] Broadhead, Geol. Missouri, 1873-74, p. 121.
[63] Amer. Nat., IV, pp. 61-62.
[64] LeConte, Proc. Phil. Acad., 1852, pp. 5-6.
[65] Bull. Geol. Soc. Amer., XXII, pp. 211-212.

Neohipparion gratum[65a]
Equus complicatus
Equus niobrarensis
Camelops kansanus?
Elephas columbi

4. *Kansas*

The Kansan ice sheet overran a small part of northeastern Kansas. Beneath this till sheet the remains of vertebrates have been found which are evidently referable to the Aftonian stage. Lucas[66] gives the following reference to an extinct bison from this area: Millwood, Leavenworth County, 25 feet below the surface. Savage[67] has described a fossiliferous horizon in Douglas County southwest of Lawrence, near the Wakarusa River, which is certainly referable to the Aftonian. It is greatly to be regretted that the mussel (muscle) shells were not identified as to species. Of this deposit Savage says "The (mastodon) jaw was found in what was once the bottom of a fresh water lake or estuary, which extended for several miles both up and down the creek; its boundaries have not yet been determined, nor perhaps ever can be with exactness. That it extends out beneath the bottom lands adjoining, is proven by the many springs which issue from it in different localities up and down the stream, and it can be traced each way from where the jaw was found, some ten or twelve miles in extent. Besides the thick layer of muscle shells which line this ancient lake-bed, we find the trunks of old trees protruding, as well as small sandy concretions containing net-veined leaves within them. In addition to these layers of muscle shells, old trees and concretions, we also find bones of what appear to be the remains of the buffalo, antelope, elk, and some other animals as yet undertermined; but all in an unfossilized state. This goes to prove that the animals whose bones we find along the same horizon with the mastodon, and are not fossilized, did not live contemporaneously with the mastodon whose jaw was found fossilized. We conclude then, that the mastodon jaw, though not way-worn at all, was washed into this old lake-bed after fossilization had taken place, and may be all of the animal that was preserved.

"I might also add, that Mr. M. Sayler, during last summer, explored the banks of the Wakarusa for some ten or twelve miles by boat; his explorations only confirm our own previously made, and added considerally to our previous collection of unfossilized bones.

"This lake-bed in which the mastodon jaw was found is about twenty-five feet below the present surface of the ground. Whatever fossil treasures are in this locality we cannot now determine; but so many bones have already been found that we already speak of it as the Bone-bed of the Wakarusa."

[65a] Hay, Iowa Geol. Survey, XXIII, p. 149.
[66] Proc. U. S. Nat. Mus., XXI, pp. 751.
[67] Trans. Kansas Acad. Sci., VI, pp. 10-11.

A tusk and tooth of a mastodon have been found in eighteen Mile Creek, Franklin County, but the horizon is doubtful, altho it may have been Aftonian.[68] The same holds true of the horn-core of *Bison alleni*, which was fished from the bed of the Big Blue River, a few miles from Manhattan, Riley County.[69] This was at first referred to *Bison latifrons*.

In Linn County,[69a] in coal shaft number 2, three and one-half miles southwest of Biocourt, in the valley of the Marias des Cygnes, the skull of *Castoroides* was found at a depth of 34 feet in a layer of sedimentary material of a bluish color overlying a deposit of sandy conglomerate. The deposit is believed to be the same as that at Trading Post, which was above a conglomerate and contained bones of elephant, horse, camel, etc. A section at Trading Post exhibited the following strata (p. 391):

Black loam	6	feet
Marly clay	12	"
Blue and yellow marl, verging into shale	12	"
Bluish silt, with bones	1½	"
Conglomerate, lying on the heavy Bethany Falls limestone	1½	"
Height of section	33	"

The deposit at Biocourt is believed to be Aftonian and the skull has been named *Castoroides kansensis*.

5. *South Dakota*

In South Dakota, *Castoroides*[70] has been recorded by Calvin from Sioux Falls. Todd[71] reports wood from wells in the lower part of the till which he refers to a preglacial or circumglacial forest. It is probably an Aftonian forest overriden by the Kansan ice. A section three and a half miles west of Fairview, Lincoln County, on the Big Sioux River, apparently includes the Aftonian.[72] The section is shown below:

Loess	6–10 feet.
Till with irregular stratified sand strata toward the bottom. The lower 20 feet is blue and almost free from pebbles	100–110 feet.
Fine sand with large rusty concretions of upper portions and a few fragments of large, pearly shells (Unios). The stratum is of undeterminable thickness	20 feet.
Unexposed. Probably much of it is a pebbleless clay of Cretaceous age	110 feet.

The sand containing Unios is apparently referable to the Aftonian interval.

[68] Wheeler, Trans. Kansas Acad. Sci., VI, p. 11.
[69] Mudge, *op. cit.*, V, pp. 9-10; Hay, Iowa Geol. Surv., XXIII, p. 326.
[69a] Martin, Kansas Univ. Sci. Bull., VI, No. 6, pp. 389-396, 1912.
[70] Bull. Geol. Soc. Amer., XXII, p. 215.
[71] Bull. 158, U. S. Geol. Surv., p. 121.
[72] *Op. cit.*, p. 83.

Todd[73] records a dark old soil in the Big Sioux Valley, Minnehaha County, east of Sioux Falls, between two till sheets, and lists certain mollusks from the same horizon. Wilder[74] has published a section in which these mollusks occur. According to Carman[75] and Shimek,[76] the territory in the immediate vicinity of Sioux Falls is covered by Kansan drift, and hence the strata containing life which lie beneath the till must be Aftonian. There is no Wisconsin till in this region. Wilder's section and list of fossils appear below:

Cutting on I. C. RR., one half mile east of Sioux Falls.

5. Sandy loess, in places sand	1–3 feet.
4. Drift, unoxidized, with fresh pebbles	6–10 feet.
3. Silt, slate color, with shells	3 feet.
2. Gravel, stained, partially decayed	1–2 feet.
1. Drift with ferretto very distinct	15 feet.

The following fossils have been reported from No. 3.

Planorbis bicarinatus (=*antrosus*)
" *parvus*
Physa heterostropha
Galba caperata
Valvata tricarinata
Pisidium compressum
Sphaerium sulcatum (=*simile*)
Vallonia costata (1 specimen)
Mud turtle
Equus species (cervical vertebrae)
Smaller bones (undeterminable)

From near "the brewery," in Sioux Falls, two species of mollusks have been recorded: *Galba caperata* and *Planorbis albus*.

Recently, Shimek has given special attention to the region about Sioux Falls and many sections are described by him which contain fossils referable to the Aftonian interval.[77]

At the Otis mill-site section, in Union County, situated on the west side of the Big Sioux River, opposite Chattsworth, Iowa, a dark fossiliferous silt resting on the Cretaceous, contains the following mollusks:

Planorbis bicarinatus (=*antrosus*)
" *dilatatus*
Segmentina armigera
Physa gyrina
Galba reflexa
" *humilis modicella*
Valvata tricarinata
Amnicola species
Pisidium species
Sphaerium sulcatum (=*simile*)
Unio, fragments
Pyramidula cronkhitei anthonyi
Strobilops, fragment

In Sioux Falls the sections indicate that the Kansan ice ploughed up the Aftonian Interglacial silts, causing them to lie between two beds of Kansan

[73] Proc. Iowa Acad. Sci., VI, pp. 122-130.
[74] Geol. Iowa, X, p. 127.
[75] Proc. Iowa Acad. Sci., XX, pp. 237-250.
[76] Bull. Geol. Soc. Amer. XXIII, pp. 125-154.
[77] Bull. Geol. Soc. Amer., XXIII, pp. 125-154, 1912.

till in some places. The section in the cutting of the Illinois Central Railway, as interpreted by Shimek, is shown below.

Sandy, somewhat loess-like stratum, possibly aeolian	2–5 feet.
Gray, weathered drift, probably Kansan	7–9 feet.
Gravel, sand, and silt:	
Sand, gravel, and boulders	1–2 feet.
Silt, with sand and pebbles, ferruginous	2–4 feet.
Sand, gravel, and boulders	5–6 feet.
Weathered gray drift, probably Kansan, exposed	2 feet.

From the silt a number of mollusks were obtained together with the bones of a horse.[78]

* *Planorbis bicarinatus* (=*antrosus*)	*Galba reflexa*
* " *parvus*	* " *caperata*
" *dilatatus*	" *humilis modicella*
Ancylus rivularis	* *Pisidium compressum*
Valvata tricarinata	" *abditum* (?)
Amnicola species	*Sphaerium sulcatum* (=*simile*)
Segmentina armigera	*Anodonta imbecilis* (?)
* *Physa integra*	* *Vallonia costata*
" *sayi*(?)	*Equus scotti* (*E. laurentius*, vide Hay)

In the Collins sand pit the following evidences of life were observed:[79]

Unio species	*Equus scotti* (*E. niobrarensis*, vide Hay)
Sphaerium sulcatum (=*simile*)	*Castoroides* species

Mastodon and musk ox bones are recorded by Todd from lower strata east of Sioux Falls, near the Big Sioux River.[80]

6. *Montana*

Alden[80a] records a pre-Wisconsin glacial drift in the region of Glacier National Park which is thot possibly to correspond with the Nebraskan or Kansan drift sheets. A second pre-Wisconsin is also thot possibly to be represented. A section on St. Mary River north of Sloan's Ranch, just north of the International Boundary, exhibits the following strata:

Northeastern till, containing crystalline boulders	
Loess, sandy at top	6 feet
Soil, black clayey loam, consisting of the weathered surface of the lower loess bed	10 feet
Typical loess, containing concretions, hard shells, and bones of small animals	5 feet
Northeastern drift containing many decomposed boulders	2 feet
Shale	

[78] Those species marked with an * were included in Todds list, where, however, *Physa integra* is identified as *Physa heterostropha.*

[79] Calvin, Bull. Geol. Soc. Amer., XXII, pp. 211-212.

[80] Bull. No. 158, U. S. Geol. Surv., p. 85.

[80a] Bull. Geol. Soc. Amer., XXIV, p. 546, 1913.

7. *Minnesota*

It is not definitely known how far north the Aftonian deposits extend, but it is believed that they are represented in the southern part of Minnesota.

Chamberlin[81] has correlated with the Aftonian certain peaty deposits in the basin of Lake Agassiz, together with other peat beds between the two till sheets in southern Minnesota, described by Winchell. At this time, however, the pre-Kansan or Nebraskan till sheet was but little known, and the Aftonian was placed above the Kansan. The recognition of the Aftonian as an interval between the Kansan and the Nebraskan, places some of these deposits from Minnesota above the Kansan, and hence correlates them with the Yarmouth Interglacial stage. A number of Minnesota records, however, appear to be referable to the Aftonian interval.

In Wilkin County,[82] at Mitchell, a well record gave the following section:

Soil	2	feet.
Yellowish-gray till	6	"
Gray sand	½	"
Dark bluish till	18	"
Sandy black mud	x	"

The sandy black mud contained many small gastropod shells. The dark blue till is evidently Kansan and the shells are referable therefore to the Aftonian interval.

In McLeod County, a number of wells encountered mollusks at various depths.[83] A boring from the Stewart railroad well descended to a considerable depth, as noted below:

Yellowish till	20 feet
Dark bluish till	240 feet
Sand with gravel	5 feet
Height of section	265 feet

At 100 feet, in a thin muddy layer, shells were found, and at 110 feet more shells. At 177 feet the trunk of a tree was encountered. In the sand and gravel at the bottom a number of fragments of bones were found. The dark bluish till includes both Wisconsin and Kansan till, and the shells at 100 and 110 feet are evidently referable to the Yarmouth interval. The bones in the gravel at the bottom are possibly Aftonian.

In Cottonwood County gastropod shells and wood have been found 60 feet below the surface at Windom, and in Jackson County[84] wood and small

[81] Journ. Geol., III, pp. 272-273, 1895.
[82] Geol. Min., Final Rep., II, p. 529.
[83] *Op. cit.*, pp. 186-187.
[84] *Op. cit.*, I, p. 511.

gastropod shells are reported from a depth of 100 feet. The great depths of these deposits indicate that they underlie the Kansan drift and are therefore referable to the Aftonian interval. The records from Murray,[85] Nobles,[86] and Rock counties[87] also apparently belong to the same horizon. From the last, at Luverne, clam shells and wood are reported from a depth of 81 feet. Red cedar and tamarack occur in these strata. It is also extremely probable that the old soils reported from Olmsted,[87] Filmore, and Winona counties should be referred to the Aftonian stage.

8. *Wisconsin*

Few evidences of Aftonian life have been observed from this state. An old, pre-Kansan drift has been recorded by Wiedman[88] who describes it as "a very old, thin drift." Koehler[88a] describes an old forest bed 4 to 12 inches thick, near Woodville, St. Croix Co., which appears to be referable to the Aftonian interval. The wood was identified as spruce. The order of strata was as follows:

Illinoian drift
Weathered soil
Kansan drift
Old forest bed
Pre-Kansan drift

9. *Illinois*

In Illinois, Aftonian deposits are apparently indicated in several places. At Bloomington, McLean County, a well section passes thru many deposits, showing the Aftonian at the base.[89]

1. Surface soil and brown clay (Wisconsin	10 feet.
2. Blue clay (Wisconsin)	40 "
3. Gravelly hard pan (Wisconsin)	60 "
4. Black mold with pieces of wood (Sangamon)	13 "
5. Hardpan and clay (Illinoian)	89 "
6. Black mold (Yarmouth)	6 "
7. Blue clay (Kansan)	34 "
8. Sand, buff and drab, with fossil shells (Aftonian)	2 "
Height of section	252 "

Bannister[90] records *Helicina occulta* from No. 8 and suggests that the deposit may be loess.

[85] *Op. cit.*, I, p. 529.
[86] *Op. cit.*, p. 530.
[87] *Op. cit.*, p. 553; 264; 312.
[88] Science, N. S., XXXVII, No. 951, p. 457, 1913.
[88a] American Forestry, XXII, pp. 92-93, 1916.
[89] Leverett, Illinois Glacial Lobe, p. 108.
[90] Geol. Illinois, IV, p. 178.

In the vicinity of Rock Island several exposures referable (apparently) to the Aftonian occur,[91] and a well section is given by Leverett which is reproduced below:

8. Yellow till (probably Illinoian)	5 feet.
7. Black muck (Yarmouth?)	1 "
6. Brown till (leached 2 or 3 feet)	7 "
5. Blue till (probably Kansan)	4 "
4. Black calcareous silt, with gastropod fossils	8 "
3. Black muck	5 "
2. Green muck with a few local pebbles	5 "
1. Coal measure shale	x "
Height of section	34 "

The gastropod shells in No. 4 were identified as follows:

Helicina occulta *Pyramidula cronkhitei anthonyi*
Pupa alticola *Succinea avara*

Similar deposits occur in the b'uffs east of Cordova, Illinois, and Clinton, Iowa.

How far eastward the Aftonian biota may have extended is not at present definitely known. Like the fauna and flota of the Pliocene, it was probably widely distributed in all directions. Several deposits outside of the southern limits of the ice sheets may possibly be correlated with this stage, as for example the Hay Springs, Nebraska, fauna, and the Christmas Lake, Oregon, fauna.

10. *Canada*

No deposits of unquestionable Aftonian age are known from Canada. Coleman[92] in a late paper refers the Toronto Interglacial deposits to the Aftonian interval. The fauna of these deposits seems more like that of the Yarmouth or Sangamon, especially the mammals. The deposits have usually been classed as post-Illinoian (Sangamon) and they are so considered in this paper. More conclusive data seem necessary to correlate these deposits with the Aftonian.

A new species of plant (*Ficus*) found in interglacial deposits of the Kootenay Valley,[93] British Columbia, may belong to the Aftonian interval, as well as the Montana deposits described by Alden and mentioned on a previous page of this work. No age is given by Hollick. It is also possible that they may be of Yarmouth age and post-Kansan.

[91] Leverett, Mon. XXXVIII, p. 114; Udden, Proc. Iowa Acad. Sci., V, p. 103.
[92] Bull. Geol. Soc. Amer., XXVI, pp. 243-254, 1915.
[93] Hollick, Bull. Geol. Soc. Amer., XXVI, p. 159, 1915.

III. Systematic Catalog of the Biota Referred to the Aftonian Interglacial Interval

PLANTS

BRYOPHYTA

Hypnaceae

Camptothecium nitens (Schreb.) Schimp. = *Hypnum nitens.*
Drepanocladus fluitans (L.) Warnst. = " *fluitans.*
" *revolvens* Swartz. = " *revolvens.*
Calliergon richardsoni Lesq. and Jams. = " *richardsoni.*

PTERIDOPHYTA

Species indet.

SPERMATOPHYTA

GYMNOSPERMAE

Pinaceae

Pinus species
Larix laricina (DuRoi) Koch = *L. americana.*
Picea species.
" *mariana* (Mill.) BSP. = *Abies nigra* Link.

ANGIOSPERMAE

MONOCOTYLEDONAE

Gramineae

Species indet.

DICOTELEDONEAE

Salicaceae

Populus species

Juglandaceae

Juglans species

Urticaceae

Ulmus species

Vitaceae

Vitis species

ANIMALS

MOLLUSCA

PELECYPODA

Unionidae

Quadrula metanevra Raf.
Anodonta imbecilis Say (?)
Lampsilis anodontoides (Lea)

Sphaeriidae

Sphaerium sulcatum (Lam.)	*Pisidium abditum* (Hald.)
" *striatinum* (Lam.)	" *compressum* (Prime)

GASTROPODA

Helicinidae

Helicina occulta Lam.	

Valvatidae

Valavta tricarinata Say	*Valvata bicarinata* Lea

Amnicolidae

Amnicola species	*Amnicola emarginata* Küster

Physidae

Physa integra Hald.	*Physa gyrina* Say
" *sayi*? Tappan.	*Aplexa hypnorum* (Linn.)

Ancylidae

Ancylus rivularis Say	

Planorbidae

Planorbis antrosus Conrad	*Planorbis albus* Müller (=*hirsutus* Gld.)
" *parvus* Say	*Segmentina armigera* (Say)
" *dilatatus* Gould	

Lymnaeidae

Galba obrussa (Say)	*Galba caperata* (Say)
" *galbana* (Say)	" *palustris* (Müller)
" *humilis modicalla* (Say)	" *reflexa* (Say)

Auriculidae

Carychium exiguum (Say)	*Carychium exile* H. C. Lea

Succineidae

Succinea ovalis Say	*Succinea retusa* Lea
" *avara* Say	

Valloniidae

Vallonia gracilicosta Reinh.	*Vallonia costata* (Müller)

Pupillidae

Bifidaria armifera (Say)	*Strobilops labyrinthica* (Say)
" *contracta* (Say)	" *virgo* (Pilsbry)

Endodontidae

Sphyradium edentulum alticola (Ingersoll)	*Helicodiscus parallelus* (Say)
Pyramidula cronkhitei anthonyi Pilsbry	*Pyramidula alternata* (Say)

Zonitidae

Zonitoides arborea (Say)	*Euconulus fulvus* (Müller)
" *minuscula* (Binney)	*Vitrea hammonis* (Ström.)

Helicidae

Polygyra monodon (Rackett)	*Polygyra profunda* (Say)
" *multilineata* (Say)	

INSECTA

COLEOPTERA

Wing cases, species undetermined

VERTEBRATA

REPTILIA

Mud turtle

MAMMALIA[94]

MEGATHERIIDAE

* *Megalonyx leidyi*? Lindahl
* *Mylodon harlani*? Owen

EQUIDAE

* *Equus complicatus* Leidy
* " *laurentius* Hay
* " *niobrarensis* Hay
* *Equus excelsus* Leidy
* *Neohipparion gratum* (Leidy)

TAYASSUIDAE

* *Mylohyus*? *temerarius* Hay
* *Platygonus compressus* Le Conte

CAMELIDAE

* *Camelops kansanus* Leidy?
* *Camelus* species

CERVIDAE

* *Alces shimeki* Hay

BOVIDAE

* *Aftonius calvini* Hay
* *Bison*, cf. *alleni* Marsh

ELEPHANTIDAE

* *Mammut americanum* (Kerr)
* " *progenium* Hay
* *Rhabdobunus mirificus* (Leidy)
* *Elephas primigenius* Blum.
* " *columbi* Falconer
* " *imperator* Leidy

CASTORIDAE

Castor canadensis

CASTOROIDIDAE

* *Castoroides ohioensis* Foster
* " *kansensis* Martin

URSIDAE

Ursus americanus Pallas

IV. SUMMARY

The Aftonian Interglacial Stage is known to have extended from south central Minnesota, south to northern Missouri, and from eastern Nebraska and South Dakota eastward to western Illinois and Wisconsin. It has been definitely recorded from almost every part of Iowa; its wide distribution is shown by the list of counties (39) indicated below.

Buchanan	Fayette	Lyon	Pottawattamie
Benton	Fremont	Linn	Sioux

[94] An * indicates that the animal is extinct.

Buena Vista	Guthrie	Monona	Union
Chickasaw	Harrison	Mitchell	Washington
Cherokee	Hancock	Mills	Wayne
Clay	Henry	Marshall	Woodbury
Cedar	Howard	Normal	Winnebago
Decatur	Iowa	Obrien	Worth
Dubuque	Johnson	Plymouth	Wapello
Delaware	Kossuth	Powershiek	

In the adjoining states it is known from the following counties:

Nebraska

Cedar	Knox	Douglas
	Linn	

South Dakota

Union	Minnehaha	Lincoln

Minnesota

Cottonwood	McLeod	Rock
Jackson	Murray	Wilkin
	Nobles	

Missouri

Atchison	Cass	Harrison
Bates	Daviess	Macon
Benton		Vernon

Kansas

Leavenworth	Douglas

Illinois

McLean	Rock Island

Wisconsin

St. Croix

The Aftonian was a time of luxuriant forests, the climate was moist, and the winters were not too severe for such animals as the elephant, horse, and peccary. The types of mollusks indicate a climate not essentially different from that of today. The fresh water mollusks also indicate the presence of large streams, while the land snails attest the presence of a rich flora. A study of the entire biota reveals two types of life: (1) a warm temperate, in which the naiads and other mollusks and the larger part of the mammals lived, and (2) a cold temperate climate in which a boreal flora flourished. Shimek remarks that the molluscan fauna of the Aftonian suggests aquatic and low ground conditions, but the mammal fauna suggests also upland or prairie conditions. It is probable that both types of topography prevailed.

Reviewing the biota, it is observed that 14 species of plants are represented and 75 species of animals, distributed as follows:

Mollusks	50 species
Insects (wings)	x "
Vertebrates	25 "

Of these all are now living with the exception of a large part of the mammals of which 23 or 92 percent are extinct. The mammalian fauna resembles most closely the fauna of the Equus zone or Sheridan formation described by Osborn. It likewise resembles the fauna of the bone caves of Pennsylvania as well as the Hay Springs fauna of Nebraska and Hay has stated his belief that all of these deposits should be referred to the Aftonian.[95] There is clearly a very close resemblance between the species represented, and particularly between the extinct species, but this would most likely be the case in the first interglacial interval, not only for the reason that the large mammals could find refuge south of the ice sheet, but also because all of the species undoubtedly lived in abundance in the region south of the affected territory, where the environment was possibly but little changed, and formed a reserve fauna which migrated northward as soon as the Aftonian climate became favorable.

[95] Smith. Mis. Coll., LIX, p. 15.

CHAPTER VIII

THE KANSAN ICE INVASION AND THE YARMOUTH INTERGLACIAL INTERVAL

I. The Kansan Ice Invasion

Following the Aftonian Interglacial interval, climatic conditions again became severe and a second ice sheet, the Kansan, advanced and covered a large portion of the United States (Plate XLVI). East of the 110th meridian the ice sheet extended a short distance south and west of the Missouri River in Montana, the Dakotas, Nebraska, Kansas and Missouri. The largest known lobe extended southward west of the Mississippi River and the driftless area, spreading entirely over Iowa and entering Nebraska, Kansas, and Missouri, as well as a narrow strip in western Illinois.

Another lobe entered Illinois but its extent is not known as it is completely covered by the later Illinoian ice sheet. The Kansan has been definitely located beneath the Illinoian till, however, and its presence is beyond question. The extent of this till beneath later glacial deposits is not known. An old till sheet is known in northern Pennsylvania, but whether it is Kansan or Nebraskan has not been definitely determined.[1]

The Kansan ice picked up pieces of wood, tree trunks and branches and other material on the surface of the Aftonian soil. In some places, as in Monona and Harrison counties, Iowa, the Kansan ice ploughed up the Aftonian and Nebraskan deposits, either incorporating the frozen gravel and sand in the base of itself, or pushing these deposits until they were either vertical or actually lay over the Kansan deposits.[2]

II. The Yarmouth Interglacial Interval

This interglacial interval is better developed and has been more fully studied in the states of Iowa and Illinois. The sands, gravels, silts, and mucks have preserved a well marked fauna of which the largest number of

[1] Consult the following references for information on this point:
Butts, Warren Folio, U. S. Geol. Surv., No. 172, pp. 6-7.
Leverett, Mon. U.S. Geol. Surv., XLI, pp. 253-254.
Munn, Sewickley Folio, U. S. Geol. Surv., No. 176, p. 6.
Willard, Tower Folio, U. S. Geol. Surv., No. 168, p. 2.
Williams, Proc. Amer. Phil. Soc., XXXVII, pp. 84-87.

[2] Shimek, Iowa Geol. Surv., XX, p. 351.

species, however, are terrestrial. The deposits are of three kinds: (1) sands and gravels, (2) muck and old soils, and (3) loess or aeolian sands. The latter is widespread over Iowa and portions of the adjoining states and contains an abundant and varied fauna. To the above may be added the 'Gumbo' or Loveland formation, which, however, is never fossiliferous in the typical deposit. This is a heavy clay and is believed to have "been formed during the melting of the Kansan ice when silt was carried into ice-bound basins, these being located at first on the higher ridges where the thinner ice was the first to melt, and when the ice finally disappeared these masses of silt, often lens-shaped, were spread upon the underlying Kansan drift."[3]

The Loveland has been called loess by many geologists, and its silty character has been the cause of much of the controversy as to whether the loess was water laid or wind laid. Another deposit formed at a little later stage is the Buchanan gravels, which are widespread in Iowa and other states. Chronologically the post-Kansan deposits stand as follows, reading from the lower stratum upward:

V. Post-Kansan loess
IV. Yarmouth soil horizon
III. Buchanan gravels
II. Loveland silt
I. Kansan drift

I. THE YARMOUTH SOIL AND WEATHERED ZONE

The name Yarmouth was given by Leverett[4] to a soil and weathered zone which lies between the overlapping portions of the Kansan and Illinoian drift sheets in eastern Iowa. Old soils and weathered zones occur in parts of Iowa, Illinois, and other states which are believed to be referable to this stage. A typical section, from a well near Yarmouth, Des Moines County, Iowa, showing the position of the interglacial deposits, is given below.[5]

7. Soil and loam (Iowan loess)	4 feet
6. Brownish yellow till (Illinoian)	20 "
5. Gray till (Illinoian)	10 "
4. Peat bed with twigs and bones (Yarmouth)	15 "
3. Gray or ashy sandy clay, containing wood (Yarmouth)	12 "
2. Fine sand (Yarmouth)	16 "
1. Yellow sandy till with few pebbles (Kansan)	33 "
Height of Section	110 "

[3] Shimek, Geol. Iowa, XX, p. 373. See also Kay, Science, N.S., XLIV, p. 637, 1916, for the term "Gumbotill."

[4] Illinois Glacial Lobe, p. 119; Proc. Iowa Acad. Sci., V, pp. 81-86.

[5] Leverett, Proc. Iowa Acad. Sci., V, p. 82; Ill. Glacial Lobe, p. 42.

The Yarmouth stratum No. 4 contained the bones of the following mammals:

Lepus sylvaticus *Mephitis mephitica*

Deposits of Yarmouth age have been observed near West Point and Denmark, Lee County, Davenport, Iowa, and near Woodville, Payson, and Quincy, Adams County, Illinois.

II. DISTRIBUTION OF THE YARMOUTH BIOTA

1. IOWA

The Yarmouth is represented near Davenport, Scott County, from which place several good sections have been recorded. Pratt[6] recognized this old soil horizon many years ago and published an excellent section, which is copied below. The interpretations are the writer's, based on the works of Leverett and other geologists.

1. Recent soil	1 foot
2. Yellow clay (loess) with *Succinea obliqua*, *S. avara*, *Helicina occulta*. *Pupa fallax*, *H. striatella*, (Illinoian loess) about	20 feet
3. Bluish-gray clay, with shells of above, mammoth remains at junction of (2) and (3). (Kansan loess)	3–5 "
4. Brown peat with *Hypnum aduncum* and pieces of coniferous wood (Yarmouth)	1 foot
5. Ancient soil, dark brown color (Yarmouth soil)	2 feet
6. Boulder clay (blue clay) Kansan till	18 "

The section was in a cut made by the C. R. I. & P. R. R. west of Davenport, and is interesting as showing evidence of erosion between 3 and 4, evidently accomplished previous to the deposition of the loess stratum number 3. Webster[7] later uses the same section, adding the remains of *Coleoptera* from the ancient soil number 5. Shimek[8] refers the old soil and peat horizons to the Aftonian and the blue clay to the Nebraskan till, but this disposition cannot be correct, the underlying till sheet being clearly Kansan.

Leverett[9] has published several sections from Davenport, one of which, along Eighth Street between Myrtle and Vine streets, is shown below.

Iowan loess	30 feet
Reddish-brown surface of Illinoian till sheet, leached and stained during Sangamon Interglacial Stage	2½–3 feet
Brown calcareous till, crumbling readily; a characteristic Illinoian till	15 feet
Ash-colored gummy clay with black streaks, apparently of humus, representing the Yarmouth Interglacial Stage	2–3 feet

[6] Proc. Daven. Acad. Sci., I, p. 97, 1876.
[7] Amer. Nat., XXII, pp. 415-416, 1888.
[8] Geol. Iowa, XX, p. 376.
[9] Illinois Glacial Lobe, p. 45; the Iowan loess also includes the Illinoian loess in its lower part.

Brown till, calcareous, fracturing in cubic blocks, color changing to grayish blue at 12–15 feet; a characteristic Kansan till	25	feet
Height of section about..	75	feet

In Lee County, in the bluffs near Fort Madison, the Kansan till contains vegetation among which Penhallow identified:[10]

Larix americana?
Taxus canadensis?
Taxus species

The vegetation is said by Keyes to be embeded in the blue till, but no depth is stated. As the Kansan is here 60 feet in thickness, and is overlaid by yellowish Illinoian drift, it is assumed that the organic remains were in the upper part of the Kansan drift, and hence of Yarmouth age. In the same county,[11] "between Fort Madison and Montrose there are high bottoms, consisting of beds of sand and gravel, the surface of which is from 20 to 30 feet above the present high water mark. Along the rapids there is a bed of Unios in band-like form, extending on both sides of the river at an elevation from 15 to 20 feet above present high water mark, nearly the whole distance from Nauvoo to Keokuk. Just below Mansion House at Nauvoo, the mussel bed is 25 feet above ordinary level of the river. The shells are white and waterworn, the deposit 12 to 18 inches thick." The Unios mentioned have not been identified. Like the benches along the Missouri River, these high bottoms are probably remnants of the old Kansan drift plain and hence the Unios may be referred to the Yarmouth Interglacial interval.

Along the rivers in Plymouth, Harrison, and Monona counties, extensive benches occur which have been mistaken for river terraces. These are said by Shimek[12] to be remnants of the old drift plain showing the same structure as the Kansan drift. "Near the mouth of Broken Kettle Creek, Plymouth County, there is a higher terrace very faintly cut in the loess. Its upper surface is marked by the presence of Unios 45 feet above low water in the Sioux. This level corresponds to the flat and well-marked bottom land found in the upper portion of Broken Kettle Creek. The Unios occur in little groups or colonies, nested together along this horizon, and at the same horizon ordinary loess fossils occur. The same phenomena are found in Woodbury County, at North Riverside, though at a lower horizon relative to the present water level. In Monona County, near Castana and Turin, there is a very well marked loess

[10] Keyes, Geol. Surv. Iowa, III, pp. 357-358.
[11] Worthen, Geol. Surv. Iowa, I, p. 186, 1858.
[12] Geol. Iowa, XX, p. 291.

terrace about 70 feet above the river and similar terraces are common in the region."[13] Shimek[14] lists the species found at the above locality, as follows:

Unio anodontoides	*Unio rubiginosus*
" *donaciformis*	" *undulatus*
" *elegans*	*Succinea lineata*
" *pustulosus*	*Helicodiscus lineatus*

Yarmouth soil, 12-18 inches thick, has been observed, between Kansan drift and loess, in Washington and Hancock townships, near Dalton.[13]

At Sioux City[15] three species of naiads have been obtained from loess-like silt.

Unio undulatus
" *rubiginosus*
" *pustulosus*

The mammoth, *Elephas* species, has been reported from both Cedar and Washington counties. In the former county,[16] from a creek in Springfield Township, (five miles southeast of Clarence) flowing thru Iowan drift underlaid by Kansan loess and till.[17] Here a bed of white alluvial clay is overlaid by gravel, but it is not known from which deposit the mammoth teeth came. In sect. 14, T. 74 N, R. 8 W, Washington County,[18] the bones of this animal were found in an area fifteen feet square in a deposit of black mud and vegetable mold with some clay, six feet below the surface of the ground.

In Linn County, the following deposits are shown in a section at Bertram, near the mouth of Big Creek:[19]

5. Loess-like loam	3 feet
4. Sand interstratified with sandy clay	4 "
3. Sand, finely and horizontally stratified, fine above, growing coarser below (Iowan)	30 "
2. Sand and gravel, with cobble stones	3 "
1. Slope of fine whitish clay to water in creek	6 "
Height of section	46 "

In a gravel pit belonging to the C. & N. W. R. R., across the creek from the above section, coniferous wood was found between numbers 2 and 3. Bones of mastodon, mammoth, and buffalo are reported to be frequently found in

[13] Bain, Geol. Surv. Iowa, VIII, pp. 340; 336; 348.

[14] Proc. Iowa Acad. Sci., V, pp. 37, 44; Hay (Iowa Geol. Surv., XXIII, p. 70) states that Shimek refers the majority of these shells to the work of the aboriginal inhabitants, and they are therefore not listed with the Yarmouth fauna.

[15] Shimek, *op. cit.*, pp. 37, 44.

[16] Norton, Geol. Iowa, XI, p. 377.

[17] Gass and Pratt, Proc. Daven. Acad. Sci., III, pp. 177-178.

[18] Anderson, Augustana Lib. Pub., No. 5, p. 26.

[19] Norton, Geol. Iowa, IV, p. 173.

these deposits. Similar deposits, referable to the Yarmouth interval, are reported from Jones,[20] Allamakee,[21] and Howard[22] counties.

McGee in his classic work[23] on the Pleistocene of northeastern Iowa, records the remains of a once luxuriant flora, some of which may be of Yarmouth age. Much of the material, however, is probably of Peorian age. Logs, sticks, branches, twigs, cones, leaves, stems and roots of grasses, and other plant remains are found in peaty soils, usually at the junction of two drift sheets. From this chaotic material have been identified: *Juniperus virginiana*, elm, ash, pine, sumach, hickory, oak, walnut, tamarack, and willow.

From Emmet County, at Wallingford, fossil wood thot to be *Picea alba* (=*canadensis*) is reported by Thomas[23a] from glacial drift at a depth of 80 feet. This depth would penetrate the Wisconsin drift and reach the Kansan which apparently underlies the Wisconsin in this part of Iowa. It may, therefore, be referred to the Yarmouth interval, tho it might be of later date.

The horse, *Equus complicatus,* is reported from near Sandspring, Delaware County; it was lying on a knoll of Niagara limestone. Hay[24] infers that this may be referable to the Yarmouth stage.

a. *Post-Kansan Loess*

The Kansan drift in Iowa is covered pretty generally (tho not uniformly) with a fine, bluish or whitish loess which is highly fossiliferous. This loess extends beneath the Illinoian drift sheet to the east and beneath the Iowan and Wisconsin drift sheets in the northern part of Iowa. Just how far the deposit may extend thruout the adjoining states is not at present known, but it is believed to be of wide distribution.

In a recent paper, Alden and Leighton[24a] question the distinction between the gray and yellow loess, the two being thot to be the result of loess deposition during but one interval, the post-Iowan or Peorian, the yellow color being due to leaching. Considerable data are given by these authors which seem to support such a conclusion. If this condition should prove true of all of the loess deposits beyond the Wisconsin area, many of the records of fossils herein referred to Yarmouth and Sangamon time would have to be transferred to Peorian time. This conclusion would lead to the recognition of a distinct period during which the loess was deposited, as contended by many early geologists.

[20] Calvin, Geol. Iowa, V, pp. 65-66.
[21] Orr, Proc. Iowa Acad. Sci., XIV, p. 232.
[22] Calvin, Geol. Iowa, XII, p. 63.
[23] An. Rep. U. S. Geol. Surv., XI, pp. 487, 489.
[23a] Proc. Iowa Acad. Sci., XXIV, pp. 454-455.
[24] Science, N. S., XXX, p. 491.
[24a] Iowa Geol. Surv., 26 Ann. Rept., pp. 49-212, 1917; Leighton, Proc. Iowa Acad. Sci., pp. 87-92, 1917.

However, it has not been thot necessary to change any of the statements or lists of loess fossils appearing under the Yarmouth or Sangamon Interglacial intervals in this work. The transfer of some of these records to the Peorian interval would not materially affect the general discussion of the life of the Pleistocene Period.

At Iowa City, Johnson County, a Kansan loess occurs beneath an Iowan loess; a section given by Webster[25] is reproduced below:

1. Very fine brownish "loamy" soil	3 inches
2. Very fine and homogeneous yellowish-clayey earth (Iowan loess)	15 feet.
3. Very fine and homogeneous bluish-gray clayey earth, with fossils (Kansan loess)	5 feet.

The following fossils have been identified from the Kansan loess:[26]

Old name	Modern name
Zonites viridulus	*Vitrea hammonis*
" *limatulus*	*Pyramidula shimekii*
" *fulvus*	*Euconulus fulvus*
Patula strigosa	*Oreohelix iowensis*
" *striatella*	*Pyramidula cronkhitei anthonyi*
Ferrusacia subcylindrica	*Cochlicopa lubrica*
Pupa muscorum	*Pupilla muscorum*
" *blandi*	" *blandi*
Vertigo simplex	*Sphyradium edentulum alticola*
Mesodon multilineata	*Polygyra multilineata*
Vallonia pulchella	*Vallonia gracilicosta*
Succinea avara	*Succinea avara*
" var. *vermeta*	" *grosvenori?*
" *obliqua*	" *obliqua*
Helicina occulta	*Helicina occulta*
Limnaea desidiosa	*Galba obrussa*
Physa species	*Physa gyrina*
Pisidium species	*Pisidium* species
Egg shell of small helix	

Shimek[27] has published several lists of the mollusks of the loess of Iowa City. These lists do not separate the faunas of the post-Kansan and post-Iowan loeses; the statement is made however, that they both contain practically the same species. The species not listed by Webster are tabulated below:

Bifidaria armifera	*Pyramidula perspectiva*
" *pentodon*	" *alternata*
Vertigo ovata	*Helicodiscus parallelus*
Vitrea indentata	*Succinea* species
Zonitoides minuscula	*Galba caperata*

[25] Amer. Nat., XXII, pp. 417-419.
[26] *Op. cit.*, p. 119.
[27] Amer. Geol., I, pp. 149-152; XXVIII, p. 345.

Polygyra profunda
" *multilineata* (small form)
Galba humilis modicella

A fossiliferous Kansan loess occurs in the bluff above Hershey Avenue, Muscatine, which contains a varied molluscan fauna. Leverett[28] quotes the subjoined list, after Udden.

Helicina occulta	*Cochlicopa lubrica*
Polygyra multilineata (young, probably this species)	*Pyramidula alternata*
" *monodon*	" *perspectiva*
Strobilops virgo	" *cronkhitei anthonyi*
Bifidaria pentodon	*Succinea avara*
Pupilla blandi (listed as *muscorum*[29])	" *obliqua*
" *muscorum* (*vide* Shimek[29])	*Galba caperata*
	Valvata sincera

The Valvata evidently belongs to an earlier period than the loess, when fluviatile conditions prevailed in the Yarmouth stage. It may also have been artifically introduced at a later stage. The species is questionable, the name *sincera* formerly embracing several species, as *lewisii*, *bicarinata perdepressa*, etc.

McGee[30] has published a list of loess fossils from Muscatine, furnished by Prof. Witter, which contains several species not included in the Udden and Leverett lists. These are:

Helix fulva (=*Euconulus fulvus*)
" *pulchella* (=*Vallonia gracilicosta?*)
Pupa quarticaria (=*Bifidaria corticaria*)
" *simplex* (=*Sphyradium edentulum alticola*)

It is not known from just what horizon Witter's shells were secured and the list is therefore not available for use in the present connection. The five naiades listed (which are referred to later) belong to a later period.

At Davenport, two loesses occur above the Yarmouth deposits, one, the lower, post-Kansan (bluish-gray) and the other, the higher (yellowish in color) post-Illinoian, the interval between marking the presence of the Illinoian ice sheet. The post-Kansan loess contains the following species:[31]

Succinea obliqua	*Leucochila fallax*
" *avara*	*Pyramidula cronkhitei anthonyi*
Helicina occulta	

The tusk and molars of a mammoth were found in the upper part of the loess, at its junction with the post-Illinoian loess. It may possibly belong to

[28] Illinois Glacial Lobe, p. 174. Modern names are here used.
[29] Shimek, Amer. Geol., XXVIII, p. 346.
[30] 11th An. Rep. U. S. Geol. Surv., p. 471.
[31] Pratt, Proc. Daven. Acad. Sci., I, p. 97.

the Sangamon or post-Illinoian interval. Shimek (Bull. Geol. Soc. Amer., XXI, page 139) states that Witter's specimen was a fragment of a molar of *Elephas primigenius* from a layer of Aftonian gravel one foot thick.

At Des Moines, a loess occurs between the Kansan and Wisconsin drifts, which contains a large and varied molluscan fauna All are apparently referable to the post-Kansan interval.[32] (Modern names used.)

Gallba humilis modicella	*Strobilops labyrinthica* (perhaps *virgo*)
" *obrussa* (=*desidiosa*)	*Euconulus fulvus*
Carychium exiguum (*exile*, *vide* Shimek)	*Helicodiscus parallelus*(=*lineatus*).
Succinea obliqua	*Vallonia pulchella* (*gracilicosta*, *vide* Shimek)
" *avara*	*Zonitoides arborea*
Polygyra clausa	" *minuscula*
" *multilineata*	*Bifidaria pentodon*
" *thyroides?*	" *armifera*
" *monodon*	" *corticaria*
Pyramidula alternata	*Pupilla muscorum*
" *strigosa* (=*Oreohelix iowensis*)	*Vertigo ovata*
" *striatella* (=*cronkhitei anthonyi*)	*Helicina occulta*

Bain[33] lists the fauna of Des Moines, indicating that the loess underlies Wisconsin drift, and adds five species.

Zonitoides shimeki (=*Pyramidula shimeki*)
Pupa blandi (=*Pupilla blandi*)
Vertigo simplex (=*Sphyradium edentulum alticola*)
Cochlicopa lubrica
Limnaea caperata (=*Galba caperata*)
Pyramidula strigosa iowensis (=*Oreohelix iowensis*)

A post-Kansan loess underlies the Wisconsin drift in Storey County A good exposure has been observed, in Washington Township, along Clear and Walnut creeks, the latter showing the following section:[34]

Drift, yellowish above, bluish below (Wisconsin)	20 feet
Loess, sandy below (post-Kansan)	20 "
Clay, blue with much coarse gravel (Kansan)	exposed.

The upper four feet of the loess is stained yellow-brown along joint planes, and grades downward into massive, structureless, pale blue clayey silt containing, in places, an abundance of root casts, wood fragments and black carbonaceous spots, and emits a distinct swamp-like odor. The entire deposit

[32] McGee and Call, Amer. Journ. Sci., (iii), XXIV, pp. 202-223 (list p. 216).
[33] Geol. Iowa, VII, p. 344.
[34] Bever. Proc. Iowa Acad. Sci., VI, p. 118.

is highly calcareous and carries a rich gastropod fauna.[35] The species enumerated by Beyer are noted below:

Pyramidula shimekii
Sphyradium edentulum alticola
Pupilla muscorum
Bifidaria pentodon
Vertigo ovata
Euconulus fulvus
Polygyra multilineata
Pyramidula cronkhitei anthonyi
Vallonia gracilicosta (=*costata*)
Helicodiscus parallelus (=*lineatus*)
Succinea lineata
" *avara*
Galba humilis modicella
Planorbis antrosus (=*bicarinatus*)

The *Galba* and *Planorbis* evidently represent the period when swamps prevailed, with streams penetrating these areas. Such mollusks as *Sphyradium* and *Pyramidula shimeki* represent a later time when the region was dry and had become loess covered.

In Louisa County, about a mile north of Columbus Junction, a fossiliferous loess overlies the Kansan drift. In the lower part of the loess, which is here twelve feet thick, the mollusks indicated below occur:[36]

Pyramidula strigosa iowensis
(=*Oreohelix iowensis*)
" *perspectiva*
" *cronkhitei anthonyi*
Polygyra multilineata
Zonitoides arborea
" *shimeki* (=*Pyramidula shimeki*)
Euconulus fulvus
Vallonia gracilicosta
Sphyradium edentulum alticola
Bifidaria pentodon
Helicina occulta
Succinea avara
" *obliqua*
" *grosvenori*
Galba humilis modicella

The post-Kansan loess of Mills and Fremont Counties contains a rich fauna. Good exposures have been studied at Hamburg, in Fremont County, and at Kelly Creek and Oak Township, Mills County. Udden[37] lists the following species:

Helicina occulta
Leucochila fallax
Bifidaria armifera
" *pentodon*
Zonitoides arborea
Pyramidula alternata
" *cronkhitei anthonyi*
" *shimekii*
Helicodiscus parallelus
Vertigo bollesiana
Succinea avara
Succinea obliqua
" *grosvenori*
" *retusa*
Vallonia gracilicosta
Cochlicopa lubrica
Polygyra leai
" *multilineata*
" *hirsuta*
Vitrea hammonis
Sphyradium edentulum alticola
Pyramidula cronkhitei anthonyi (eggs)

[35] *Op. cit.*, p. 118. Modern names are used in this list.
[36] Udden, Geol. Iowa, XI, p. 113.
[37] Geol. Iowa, XII, pp. 167-175.

The post-Kansan loess is widely distributed in Harrison and Monona counties, and is highly fossiliferous in places. Shimek, who has studied this territory exhaustively, lists the following species:[38]

Vallonia gracilicosta
Polygyra monodon
" *multilineata*
Bifidaria armifera
Vertigo modesta (=*ovata*)
" *tridentata*
Sphyradium edentulum alticola
Vitrea hammonis
Euconulus fulvus
Zonitoides arborea
Eggs of small snails
Pyramidula alternata
" *shimekii*
" *cronkhitei anthonyi* (=*striatella*)
Helicodiscus parallelus
Succinea avara
" *ovalis*
Helicina occulta
Galba caperata
" *obrussa*
" *humilis modicella*

In Pottawattamie County, Kansan drift occurs overlaid by loess, the lower portion of which is referable to the post-Kansan interval. At Council Bluffs the following species occur:[39]

Helicina occulta
Vallonia gracilicosta
" *parvula*
Polygyra profunda
" *multilineata*
" *hirsuta*
" *leai*
Strobilops virgo
Bifidaria armifera
" *holzingeri*
" *contracta*
" *curvidens*
" *pentodon*
Leucochila fallax
Pupilla blandi
Vertigo bollesiana
Cochlicopa lubrica
Vitrea hammonis
" *indentata*
Euconulus fulvus
Zonitoides arborea
" *minuscula*
Pyramidula alternata
" *cronkhitei anthonyi*
" *perspectiva*
" *shimekii*
Helicodiscus parallelus
Succinea obliqua
" *grosvenori*
" *avara*
Eggs of land snail

Both post-Kansan and post-Iowan losses occur in Warren, Madison, and Page counties (vide Shimek).

McGee[40] has reported *Ovibos cavifrons* from the Council Bluffs loess, 12 feet below the surface, associated with mastodon and elephant remains, the bones of a small rodent, and several pulmoniferous mollusks.

Udden[41] lists the fauna of numerous loess deposits in Pottawattamie County, the majority of the species being from the lower (post-Kansan) loess. His list

[38] Geol. Iowa, XX, pp. 395-396; sections, pp. 379-385.

[39] Shimek, Proc. Iowa Acad. Sci., VI, p. 111; Journ. Geol., VII, p. 137. Some of these are probably also referable to the upper or post-Iowan loess, but no division is made in these papers.

[40] Amer. Journ. Sci., (iii), XXXIV, p. 217.

[41] Geol. of Iowa, XI, pp. 258-267.

includes many species noted by Shimek from Council Bluffs, with the addition of three not recorded from the latter locality.

Sphyradium edentulum alticola
Galba humilis modicella
" *caperata*

The bones of an elephant and the horn core of *Bison latifrons* (*B. occidentalis*, vide Hay) are also reported by Udden from this county, in sect. 28, James Township, T. 76 N, R. 40W, in loess at depth of 14 feet. At Carson, peat and wood are found at the base of the loess, showing that the loess was deposited on the weathered Kansan drift after an interval of time sufficient for the growth of peat and a forest.

Udden[42] reports a fauna in a terrace of loess-like silt north of Loveland, at the base of the Missouri River bluffs, which should probably be referred to the post-Kansan interval tho the presence of Unios leads to the conclusion that the deposit is not loess. The species listed are as follows:

Unio, fragments of heavy-shelled species
Helicina occulta
Succinea grosvenori
Helicodiscus parallelus
Pyramidula alternata
Bifidaria holzingeri
Leucochila fallax
Polygyra leai
Fragments of a bone

Todd[43] lists a number of loess fossils from southeastern Iowa which may be referable to the Yarmouth interval. His list is repeated below:

Hyalina binneyana[44]
" *fulva*
" *lineata*
Helix alternata
" *perspectiva*
" *striatella*
" *labyrinthica*
" *monodon*
" *leai*
" *divesta*[44]
" *multilineata*
Cionella subcylindrica
Pupa muscorum
" *blandi*
" *fallax*
" *armifera*
Vertigo gouldi[44]
Succinea decampi[44]
" *lineata*
" *avara*
" *obliqua* var. *grierii*[44]
Helicina occulta
Lymnaea parva[44]
Pomatiopsis lapidaria
Planorbis trivolvis

[42] *Op. cit.*, p. 266.
[43] Proc. Amer. A.A. Sci., XXVII, p. 235. The older nomenclature is here used.
[44] These species have not been reported from the loess by later students and the identifications are questionable.

b. *Vertebrate Animals*

The mammoth and mastodon were widely distributed in Iowa during the Yarmouth interval. Records of the remains of these animals, more or less definite, are listed by Miss Anderson,[45] from whom the following records are taken:

Mammut americanum.

Fayette County; Clermont, in gravel pit, possibly Buchanan gravels.

Henry County; in valley of Big Cedar Creek, Salem Township; the creek had washed the bones from an old bog. Also near bank of Skunk River.

Lee County; in Lost Creek, Washington Township, near Denmark.

Elephas (species not indicated).

Mills County; railroad cut between Glenwood and Pacific Junction, not far from Keg Creek, 5 to 8 feet below the surface in the upper part of the boulder clay below the loess. Malvern, in railroad crossing, from lower part of loess.

Pottawattamie County; in section 34, apparently in loess.

Powershiek County; in loess, 6 feet below the surface.

Mammoth or Mastodon.

Shelby County; in well near bank of small stream about three miles from Defiance.

A mammoth tooth is also recorded from Given, Mahaska County "from the general area of the Kansan drift."[46]

Hay (Geol. Iowa, XXIII) adds the following data relative to the mammal fauna of the Yarmouth interval. The writer cannot see, however, why the fossils from Denison (page 431) should be referred to the Sangamon interval. They seem more logically to belong to the Yarmouth interval, as the deposits appear to overly Kansan drift. The same is true of the Correctionville material.

Mammut americanum

Crawford County, Denison, Tooth (page 382)

Elaphas primigenius

Powershiek County, Grinnell. In cellar, 5-8 feet below surface, cor. Main and 4th streets, teeth and other bones. Many bones half mile from last locality, at depth of about 20 feet, (pages 444-446).

Crawford County, Denison. Teeth (page 431)

Woodbury County, Correctionville. Tooth, (page 449).

Proboscidian

Warren County, Indianola. Elephant bones one and one-half miles east of city, 6 feet below bottom of a ravine (page 84).

[45] Augustana Lib. Pub., No. 5, 1905.

Cervalces roosvelti

Crawford County, Denison. Greater part of right antler and part of skull (page 267).

Rangifer cf. *muscatinensis*

Woodbury County, Correctionville. Post-Kansan deposits. Antlers, (pages, 281-282).

Bison occidentalis.

Crawford County, Denison. Scapula (page 325).

Woodbury County, Correctionville. In Welch gravel pit, horn core and base of skull. (post-Kansan, page 325)

Harrison County. In clay at depth of 22 feet on the 'bench' or second bottom of the Boyer River (page 306).

Hamilton County. Near Webster City, sticking in gravel bar in Boone River; horn-core and part of skull, (page 323).

Symbos cavifrons

Warren County, one and one-half miles east of Indianola, in Lincoln Township. Atlas at depth of 11 feet (page 307).

Musk Ox

Warren County, Indianola. In well at depth of 38 feet beneath river bottom, in old soil. Part of humerus (page 308).

2. NEBRASKA

The Yarmouth interval is believed to be represented in eastern Nebraska, especially in the loess deposits of the Missouri bluffs. References to deposits of this are, however, rare. Todd[47] records fresh water shells from a deposit of black earth in Limekiln ravine, which is apparently referable to the Yarmouth stage. The stratum is 90 feet above high water of the Missouri River, and 15 feet above the Greenhorn limestone from which it is separated by stratified drift. Over this fossil stratum the loess lies "scores of feet thick," with a very steep slope. The till beneath the loess is evidently Kansan. Three species of mollusks are enumerated.

Sphaerium sulcatum (=*simile*)
Planorbis bicarinatus (=*antrosus*)
Planorbis, large species

The Loess

Russel[48] lists a loess fauna from Loup River, which overlies Kansan drift and is probably of post-Kansan age. Ten species are enumerated.[49]

Succinea avara	*Pupilla blandi*
" *lineata* (=*grosvenori*)	*Vallonia pulchella* (=*gracilicosta*)

[47] Elk Point Folio, U. S. G. S., No. 156, p. 4.
[48] Amer. Geol., VII, pp. 38-44.
[49] *Op. cit.*, p. 40.

Succinea verrilli[50]	*Helicodiscus lineatus* (=*parallelus*)
Pyramidula shimekii	*Helicina occulta*
" *cronkhitei anthonyi*	*Carychium exiguum*

In a cut near Hartington, Cedar County, the Wisconsin drift rests upon a calcareous marl, which contains a few fresh water shells, six species being recorded.

Valvata tricarinata	*Galba palustris?*
Planorbis parvus	*Succinea ovalis* (=*obliqua*)
Galba obrussa (=*desidiosa*)	*Sphaerium striatinum*

Todd[51] refers this deposit to the late Tertiary, probably the *Equus* beds of Cope. Similar beds are reported two or three miles east of Harrington. The most probable correlation of these beds would seem to be with the Yarmouth interval. Augheys'[52] list of loess fossils from Nebraska is so unreliable and the identilfications are plainly so erroneous that it cannot be used and must be completely ignored.

3. SOUTH DAKOTA

The Kansan ice sheet spread over the eastern half of South Dakota and upon its surface the remains of Yarmouth life have been observed. In Clark County Todd[53] observed the following section, six miles from Bradley, in section 35, Spring Valley Township:

1. Black loam	3 feet
2. Crumbly yellow clay (Wisconsin)	14 "
3. White marl, containing shells	3 "
4. Muck, containing wood and shells	9 "
5. Blue clay (evidently Kansan)	6 "
Height of section	35 feet

The white marl contained:

Valvata tricarinata	*Planorbis bicarinatus* (=*antrosus*)
Galba humilis modicella	" *parvus*

The muck contained shells similar to those of number 3, and also coniferous wood and two bivalve mollusks, *Anodonta* species and *Sphaerium sulcatum* (=*simile*). This was evidently a shallowing pond, which was finally filled with loess.

[50] This is an evident misidentification, *verrilli* being an eastern species, originally described from Anticosti Island, Gulf of St. Lawrence. Shimek says that it should be stricken from loess lists.

[51] Bull. 158, U. S. Geol. Surv., p. 73.

[52] Hayden's U. S. Geol. Surv. Col. & Adj. Terr., pp. 266-269.

[53] Proc. Iowa Acad. Sci., VI, p. 127.

In Douglas County the Yarmouth is apparently represented beneath the Wisconsin till, the deposit being seen in well sections. One such, two or three miles north of Grandview (S. E. quarter section 33, T. 100, R. 64) contained wood, cones, shells, etc. in muck, and was situated 20 feet below the surface. Todd thus refers to this material.[54] "An ancient tamarack swamp.—Near Grandview, in the southeast quarter of sec. 33, T. 100, R. 64, were found traces of more recent occupation of the region by trees. In a well which had been dug on the edge of a basin near a branch of Andes Creek, at the depth of 20 feet was found a layer of muck several inches in thickness, in which were pieces of wood with numerous fresh-water shells of nearly a dozen species. But the most remarkable thing was the stem of a hemlock or tamarack about 10 inches in diameter lying across the well, and in the muck were numerous cones, evidently of the same species. Overlying this trace of a tamarack swamp was mud of various colors and consistency, evidently washed from the surrounding hillsides. That it should be so deeply buried was chiefly explained by its connection with the channel of Andes Creek. This was conclusive evidence that the region had been occupied more or less by timber since the ice had covered the region, possibly while the second moraine was in process of formation. Similar finds are reported from wells several miles west of that place."

The overlying till here is Wisconsin, which varies greatly in thickness. The surface is yellow clay, underlaid by blue clay. The former is Wisconsin, while the latter is apparently Kansan. Prof. Todd evidently correlates the deposit with the later Wisconsin when he says "this was conclusive evidence that the region had been occupied more or less by timber since the ice had covered the region, probably while the second moraine was in process of formation." The indications are that the underlying blue clay was laid down by the Kansan ice sheet, and hence the fossil remains must be regarded as post-Kansan and pre-Wisconsin.

From this new angle of view the fossils become of great interest. The mollusks were submitted by Prof. Todd to Prof. R. Ellsworth Call, who recognized the following species:[55]

Limnophysa palustris	*Valvata sincera*
" *decidiosa*	*Segmentina armigera*
Gyraulus parvus	

Recently, the material gathered by Prof. Todd was submitted to the writer for study by Mr. W. H. Over, of the University of South Dakota museum, and fifteen species were recognized, as noted below:

Pisidium compressum	*Lymnaea stagnalis appressa*
" *variable*	*Planorbis trivolvis*

[54] Todd, Bull. 158, U. S. Geol. Surv., p. 121.
[55] *Op. cit.*, p. 121, footnote. The old nomenclature is used.

Pisidium medianum	*Planorbis antrosus*
Valvata tricarinata	" *antrosus striatus*
" *lewisii*	" *deflectus*
Succinea avara	" *parvus*
Physa species (immature)	" *exacuous*
Galba palustris	

Two species, *Segmentina armigera* and *Limnophysa* (*Galba*) *decidiosa* (=*obrussa*) mentioned by Call, were not detected in the material examined. Thirteen species are likewise included which were not mentioned by Call, possibly because the material examined by him did not contain them. *Valvata sincera* as identified by Call also proves to be *V. lewisii.*

The fauna is seen to have been large and varied. The deposit was evidently the bed of a large river or lake, and could not have been a tamarack swamp, as stated by Todd, because mollusks such as *Valvata tricarinata* and *V. lewisii* do not inhabit such a station. The tamarack log and cones mentioned probably floated from the shore and became buried in the mud. That this fauna lived in or near the present Andes Creek is very doubtful, because such an assemblage of molluscan life would scarcely be found in this kind of an environment.

4. MINNESOTA

Interglacial deposits referable to the Yarmouth interval occur in southeastern Minnesota between Kansan and Iowan tills.[55a] In Mower County there is a bed of peat 6-8 feet thick beneath 50 feet of Iowan drift.[56] Pieces of wood thot to be pine and cedar were found in the peat bed. Several other sections in this vicinity as well as in other parts of the County, show this peat bed to be widespread, to vary from 2 to 8 feet in thickness and to occur from 20 to 50 feet below the surface.

Wood, apparently from the same horizon, occurs in Dodge,[57] Steele,[58] Waseca,[59] Goodhue,[60] and Dakota[61] counties. Records from Olmsted, Fil-

[55a] Upham (The Sangamon Interglacial Stage in Minnesota and Westward) refers these interglacial deposits to the Sangamon interval As the deposits underlie Iowan till and overlie Kansan till, they may represent the entire interval between these two ice invasions. It is probable that if these deposits could be carefully studied in the light of our present interpretation of Pleistocene phenomena, a break would be found in the deposits under consideration representing the Illinoian ice invasion, if this part of the country was not glaciated at this time The deposits in question seem as logically referable to the Yarmouth as to the Sangamon interval.

[56] Winchell, Geol. Minn., Final Report, I, page 363.

[57] *Op. cit.*, I, pp. 345, 375.

[58] *Op. cit.*, I, p. 402.

[59] *Op. cit.*, I, p. 413.

[60] *Op. cit.*, II, p. 51.

[61] *Op. cit.*, II, p. 98.

more,[62] and Winona[63] counties are probably referable to the Aftonian as they lie under what is now believed to be Kansan drift. The area of the Iowan till is not definitely known. Near Moscow, Freeborn County, at depths of 35 and 50 feet below the surface, sticks, apparently of tamarack, occur in gravel and clay associated with the remains of crayfish and gastropod shells. In a well a log (tamarack?) was found 20 feet below the surface which had been gnawed by beavers (possibly *Castoroides*). Peat moss and sticks were associated with the gnawed wood. At Manchester a bed of muck was found 70 feet below the surface.[64]

In Martin County, which is covered with the Wisconsin drift, several horizons of shell beds have been reported. At Center Creek[65] a sand bed 8 feet thick underlies 60 feet of till. This sand bed contained "elm leaves and clam shells in abundance, the latter 3-4 inches long." Well diggers report shells in coarse, dark sand at depths of 20 to 60 feet below the surface, under yellow and then blue till. Gastropod shells have been reported 6 feet below the surface, underlaid and overlaid by yellow till. Some of these references doubtless include the Yarmouth beneath Iowan till but the shallower shell beds are evidently Peorian.

In Brown and Redwood counties shells and vegetation[66] are reported between till sheets. In Lyon County[67] gastropod and bivalve shells are reported in sand and gravel from 8 to 26½ feet below the surface. In Lac qui Parle County[68] wood was found at a depth of 52 feet. In Hennepin County[69] the remains of wood have been observed at various places between tills. In a well 25 feet above Red River an abundance of the remains of marshes and sedges was found at a depth of 45 feet. To just what interval this deposit should be assigned is not clear; it may be Yarmouth or it may be Aftonian. It could scarcely be post-Wisconsin.[70]

Shell deposits occur in Blue Earth County, on Blue Earth River near the Minnesota River. A section published by Owen[71] may be interpreted as follows:

1. Ash-colored clay (Wisconsin)	8	feet
2. Coarse sand with some pebbles (Wisconsin)	2	"
3. Ash-colored clay marl (Wisconsin)	7	"

[62] *Op. cit.*, I, p. 312.
[63] *Op. cit.*, I, p. 264.
[64] *Op. cit.*, I, p. 390.
[65] *Op. cit.*, I, pp. 486-487.
[66] Geol. Minn., Final Rep., I, p. 580.
[67] *Op. cit.*, I, pp. 608-609.
[68] *Op. cit.*, I, p. 630.
[69] *Op. cit.*, I, p. 306.
[70] *Op. cit.*, II, p. 529.
[71] Rep. Geol. Surv. Wis. Iowa and Minn., p. 489.

4. Sand and pebbles, with some boulders at base (Wisconsin)	8 feet
5. Sand with fresh water shells (Peorian)	½ foot
6. Sand and gravel (Iowan)	6 feet
7. Sand with fresh water shells (Yarmouth)	8 inches
8. Soil and subsoil (Yarmouth)	6 feet
Height of section	38 ft. 2 in.

From bed No. 7, ten species of mollusks were secured.

Valvata tricarinata
Amnicola limosa
Planorbis antrosus (=*bicarinatus*)
" *parvus*
Ancylus species
Lymnaea columella
Pyramidula cronkhitei anthonyi (=*striatella*)
" *alternata*
Zonitoides arborea
Sphaerium species (=*Cyclas*)

Shells and trees are reported beneath two distinct beds of till in Blue Earth County;[72] the upper till is Wisconsin and the lower is probably Iowan, the life being referable, therefore, to the Yarmouth interval. In Clay County, at Barnesville, a well boring exhibited the following strata:

Oxidized surface of till	2 feet
Yellowish till	10 "
Thin quicksand	1 "
Depth of well	13 feet

The quicksand contained branches and trunks of trees thot to be tamarack. The specimens were lying across the well, and many of them measured eight inches in diameter. The till beneath the Wisconsin at this locality is probably Kansan and the quicksand would therefore be referable to the Yarmouth interval.

In McLeod County[73] the Yarmouth is apparently represented in several well borings. One such, four and one-half miles east of Hutchinson Village, showed:

Yellow upper till	14 feet
Harder gray till	3 "
Dark bluish till	13 "
Gray sand	2 "
Depth of well	32 feet

The upper yellow till is Wisconsin as is the harder gray till. The dark bluish till is Iowan. The sand beneath, here referred to the Yarmouth interval, contained an abundance of gastropod shells.

[72] Geol. Minn., Final Rep., I, p. 441.
[73] *Op. cit.*, II, pp. 186-187.

Vertebrate remains from this interval are evidently rare in Minnesota. In Nobles County, in gravel 27 feet below the surface, the bones of *Elephas primigenius* have been found.

5. WISCONSIN

Fish remains have recently been discovered in interglacial deposits at Menomonee, Dunn County,[73a] the remains consisting of skull and a number of associated bones. The fish was evidently about two feet in length. The Menomonee clay beds are from 20 to 40 feet thick and are located in the valley of the Red Cadar River. Weidman (p. 688) says of these beds "The relation of the lacustrine clay ('Menomonee beds') to the overlying Iowan (Illinoian) glacial gravels indicate that the probable age of the clay is the interglacial stage between the Kansan and the Iowan (Illinoian), that is, between the second and third glacial stages of the Pleistocene. No definite relations of the clay beds at Menomonee to the Kansan is exhibited, the border of the Kansan being located ten or twelve miles to the west, but, based in part on other geologic data, the above inference as to age seems warranted."

A generalized section of the deposits in this vicinity is as follows:

Iowan (Illinoian) outwash gravel and coarse sand	5-10 feet
Unconformity	00 feet
Lacustrine clays 'Menomonee' beds, finely stratified silt, fine sand and calcareous clay	20-40 feet
Fine sand, resting unconformably at Menomonee on Upper Cambrian sandstone.... Maximum	150 feet

"Besides the remains (of fish), there have been found in the Menomonee clay beds the remains of various mammals such as the elephant, mastodon, reindeer, caribou, the bones of other animals, the leg bone of a bird, and also fragments of wood identified as spruce." A reindeer, *Rangifer*, is thot to be an extinct species, and is represented by both male and female antlers, the latter identified by Dr. O. P. Hay (page 689). "The fossil remains of the land mammals and of the forest trees found in the clays are only in fragmentary pieces, indicating the fact that they were carried some distance by streams, or currents along the lake shore, and dropped into the bed of the old lake. The remains of the fish, on the other hand, are fairly complete specimens, and seem clearly to indicate that these fish lived in the lake in which the clays were deposited" (page 689).

These fish remains are of great interest, they being the first bones of this class of animals to be definitely identified from interglacial deposits. The relation of the deposits, as commented upon by Weidman, seems to be with the Yarmouth interval. The deposits between the Kansan and Iowan may, how-

[73a] Hussakoff, Journ. Geol., XXIV, pp. 685-689, 1916.

ever, include also the Illinoian advance and the Sangamon interval, particularly if the Iowan was not contemporaneous with the Illinoian.

6. MISSOURI

No records of aquatic life referable to the Yarmouth interval in Missouri have been observed. Loess deposits are common along the Missouri and Mississippi rivers, but the exact horizons from which the recorded fossils were obtained are not stated. Many doubtless belong to a later period, and the published lists are not available for the study of the Yarmouth fauna on account of their ambiguity. A few of these are here recorded for the sake of completeness.

Swallow[74] and Hambach[75] both list a number of species from the loess of the Missouri River, but no definite clue is given as to their being of post-Kansan or later age. The species with their localities are indicated below.[76] The acquatic species are probably not from true loess deposits.

Mouth of Little Nemaha River.

Polygyra profunda | *Polygyra multilineata* | *Physa heterostropha*

Near mouth of Big Nemaha River.

Polygyra multilineata	*Galba elodes*
Pyramidula cronkhitei anthonyi	*Planorbis trivolvis*
Helicodiscus parallelus	

Half mile below Great Nemaha River.

Polygyra albolabris

Near mouth of Wolf River.

Sphaerium species	*Physa plicata* (=*heterostropha*)
Planorbis species	*Lymnaea*, 5-6 species
Segmentina armigera	*Pyramidula alternata*

Bellevue, Iron County.

Pyramidula alternata	*Galba fragilis* (=*palustris*)

Bluff City Landing.

Pyramidula alternata	*Succinea campestris*
Helicodiscus parallelus (=*lineatus*)	*Valvata tricarinata*
Vallonia pulchella (=*gracilicosta*?)	*Galba palustris* (=*fragilis*)
Bifidaria armifera	" *reflexa*
Circinaria concava	" 5-6 species
Polygyra thyroides	*Physa heterostropha* (=*plicata*)
" *profunda*	" *gyrina*
Succinea ovalis (=*obliqua*)	*Planorbis trivalvis*

[74] Proc. Amer. Assoc. Ad. Sci., XI, pp. 21-39, 1858.
[75] Bull. Geol. Surv. Missouri, p. 82.
[76] The recent nomenclature is used in these lists.

St. Joseph, Buchanan County.

Polygyra albolabris (=*Helix rufa*)

Lexington, LaFayette County.

Pyramidula alternata *Polygyra profunda* *Galba palustris*

Mouth of Platte River.

Polygyra multilineata	*Galba palustris*
Pyramidula cronkhitei anthonyi	" 5-6 species
Helicodiscus parallelus	*Physa heterostropha*
Vitrea indentata	" *gyrina*
Vallonia pulchella (=*minuta*)	*Aplexa hypnorum*
Bifidaria armifera	*Planorbis trivolvis*
Succinea obliqua	*Segmentina armigera*

Booneville, Cooper County.

Pyramidula cronkhitei anthonyi	*Vitrea hammonis* (=*electrina*)
Vallonia pulchella	*Helicina occulta*

Near St. Louis, St. Louis County.

Pomatiopsis lapidaria	*Circinaria concava*
Helicina occulta	*Pyramidula cronkhitei anthonyi*
Bifidaria armifera	(=*striatella*)
Pupa species	*Polygyra monodon*
Zonitoides arborea	" *hirsuta*
Vitrea hammonis (=*electrina*)	*Strobilops labyrinthica*

The seeds of *Lithospermum* are reported from the mouth of the Big Nemaha and five mammals are recorded from various localities, as noted below:

Castor fiber (=*canadensis*)	Near mouth of Big Nemaha
Elephas primigenius	Bonne Femme Creek, Boone County
Mammut americanum	St. Louis
Molar of ruminant	Near mouth of Big Nemaha
Incisors of small rodent	Near mouth of Big Nemaha

In the above lists *Physa heterostropha* (=*plicata*) is doubtful and the identification is probably erroneous. It was doubtless founded on some one of the more recently described species, perhaps *Physa crandalli*. *Succinea campestris* is strictly a southern species and the specimens upon which the identification was made were probably *grosvenori* which is common in the loess. The *Vallonia* is also probably *gracilicosta* and not *pulchella*.

The Missouri fauna is closely related to the southern region, such species as *Polygyra divesta* and *Helicina orbiculata tropica* showing this affinity. The majority of the species, however, extend well to the northward.

It is possible that the *Mastodon* (reported as *angustidens*, but now known to be *americanus*) recorded by Todd[77] from Pike County, in a creek entering

[77] Trans. Acad. Sci. St. Louis, III, pp. CXCII-CXCIII.

the Mississippi River at upper end of Clarksville, may have been derived from post-Kansan deposits.

Two records of molluscan fossils from Callaway County, Missouri,[77a] appear referable to the Yarmouth interval, occurring in post-Kansan strata. The first record apparently represents an old stream bed in which many land shells, washed from the shore, are mixed with the few fluviatile species. The second record is in typical Kansan loess and the species are all terrestrial. Of these deposits Greger says: "The first place visited was an excavation on the east bank of Middle River, a short distance below the point of its entrance into the gorge of the Missouri. At a depth of 26 feet below the level of the flood-plain of the Missouri River, in a black, sticky clay, the following species were gathered:

Polygyra profunda	*Succinea ovalis*
" *albolabris*	*Gastrodonta ligera*
" *thyroides*	*Helicina occulta*
" *elevata*	*Pyramidula solitaria*
" *clausa*	" *alternata*
" *appressa*	" *perspectiva*
" *inflecta*	*Helicodiscus parallelus*
" *fraterna*	*Campeloma subsolidum*
" *monodon*	*Pleurocera* species
" *hirsuta*	*Musculium transversum*

"The second locality examined was an exposure of typical loess in the government quarry a short distance above the town of Mokane on the M.K. & T.R.R. The full section of strata exposed in the quarry face measures approximately 70 feet; rising abruptly from the flood-plain of the river, the Jefferson City formation (Ordovician) presents a precipitous face of 60 feet followed by a layer of tough, bluish clay, interspersed with worn fragments of limestone; upon this bed of clay is deposited a layer of loess that varies in thickness but having probably an average of 9 feet. The loess is capped with a layer of soil rich in humus and supports a flora typical of the Missouri Bluff region.

"While occasional specimens of the species listed were found throughout the entire thickness of the loess, it was only in a thin zone, about 16 inches from the base, that they were collected in abundance, in fact they are so abundant in this zone as to attract attention from the highway below, by the white line they present at the top of the quarry, being even more pronounced than the Ordovician-Pleistocene contact."

It is probable that the loess deposit represents more or less continuous deposition from post-Kansan to comparatively recent times. The band of

[77a] Greger, Nautilus, XXX, pp. 64-66, 1916.

shells described as forming the distinct line probably represents the Yarmouth interval. Greger lists 22 species from the loess deposit.

Polygyra albolabris(a)	*Pyramidula solitaria*(c)
" *appressa*(a)	" *alternata*(a)
" *appressa*, small var.(c)	" *alternata*, small var.(c)
" *elevata*(a)	*Gastrodonta ligera*(r)
" *multilineata*(r)	*Helicodiscus parallelus*(c)
" *thyroides*(c)	*Vallonia pulchella*(a)
" *zaleta*?(c)	" species indet.(r)
" *fraterna*(c)	*Bifidaria contracta*(c)
" *monodon*(c)	" *armifera*(c)
" *hirsuta*(c)	" *procera*?(r)
Zonitoides arborea(r)	*Carychium exile*(a)
" *minuscula*(c)	*Helicina occulta*(c)

(a) = abundant (c) = common (r) = rare

7. KANSAS

Examples of the Yarmouth interglacial interval are rare in Kansas. Swallow[78] records the bones of a horse from near Marysville, Marshall County, from a well 45 feet below the surface, in beds of stratified sand which lie beneath the bluff formation (loess) and above the drift. The species is not named.

8. ILLINOIS

In Illinois the Yarmouth is well developed in many localities and the information at hand is sufficient to lead to the conclusion that it underlies the Illinoian drift thruout the greater part of the State. The following section is typical of the order of the strata in the western counties:[79]

Section of well at Pana, Christian County

Soil and clay (loess)	11	feet
Blue clay (loess)	4	"
Sand and gravel (Sangamon)	12	"
Hard red clay (containing wood) Illinoian	21½	"
Blue clay (Illinoian)	57	"
Black soil or forest bed (Yarmouth)	2½	"
Blue clay (Kansan)	19	"
Height of section	127	feet

In Ford County a well section indicated a different succession of strata.[80]

Yellow till (Wisconsin)	10 feet
Soft blue till (Wisconsin)	30-40 "

[78] Trans. Acad. Sci., St. Louis, II, p. 418.
[79] Leverett, Ill. Glacial Lobe, p. 107.
[80] *Op. cit.*, p. 663.

Hard blue till (Illinoian)	25-30 feet
Black muck (Yarmouth)	20 "
Sand and gravel at bottom (Buchanan gravels)	x

At Bloomington, McLean County, a well section passes thru three interglacial intervals,[81] as noted below:

1. Surface soil and brown clay (Wisconsin)	10 feet
2. Blue clay (Wisconsin)	40 "
3. Gravelly hard pan (Wisconsin)	60 "
4. Black mold with pieces of wood (Sangamon)	13 "
5. Hard pan and clay (Illinoian)	89 "
6. Black mold, etc. (Yarmouth)	6 "
7. Blue clay (Kansan)	34 "
8. Sand, buff and drab, with fossil shells (Aftonian)	2 "
9. Coal shale (Coal measures)	x
Depth of well	234 "

Bannister reports *Helicina occulta* from No. 8, which is suggested might be loess. Another shaft, a little over a mile distant, passed thru materially the same strata, with only local variations in thickeness.

Near Coatsburg, Adams County, a coal boring showed the following series of strata:[82]

1. Soil and yellow clay (loess)	6	feet
2. Gray or ashy clay, resembling a soil (Sangamon)	4	"
3. Yellow till, becoming gray or blue near bottom (Illinoian)	10-15	"
4. Blue-gray till (Illinoian)	70-75	"
5. Black soil (Yarmouth)	2½	"
6. Stratified clay (Yarmouth)	6	"
7. Tough blue clay (Kansan)	20	"
Depth of well	118	"

Worthen[83] reports wood and bones from No. 5, and lacustrine and fluviatile shells from No. 6. The loess is said to contain land shells.

a. *Silveria Formation*

Hershey[84] has given the name Silveria to certain stratified silt-like clays which underlie the Illinoian till in northwestern Illinois. These are referable

[81] Bannister, Geol. Illinois, IV, p. 178; Leverett, Ill. Glacial Lobe, pp. 108, 694.
[82] *Op. cit.*, p. 716.
[83] Geol. Illinois, IV, pp. 46-47.
[84] Amer. Journ. Sci., (iv), II, pp. 324-330, 1896, Leverett, Illinois Glacial Lobe, pp. 111-118.

to the Yarmouth interval. Three land shells are recorded from these deposits near Freeport, Stephenson County.

Succinea avara
Pupilla blandi
Pyramidula cronkhitei anthonyi

These silts, which are very thick and vary in character (including a bed of brown sand which may be an old soil), cover an extensive area in northwestern Illinois.

b. *Loess*

An excellent exposure, showing two loesses, occurs in a ravine near the line of Rock Island and Mercer counties. This section is reproduced below:[85]

Loess (post-Illinoian)	25 feet
Black soil (Sangamon)	2–3 "
Till, mainly of blue color (Illinoian)	90 "
Loess-like silt, very fossiliferous (post-Kansan)	12 "
Height of section	130 "

The following mollusks were obtained from the post-Kansan loess:[86]

Helicina occulta
Helicodiscus parallelus (=*lineatus*)
Galba humilis modicella
Pyramidula perspectiva
" *cronkhitei anthonyi* (=*striatella*)
Bifidaria armifera
Strobilops labyrinthica
Succinea avara
" *luteola*[86]
Zonitoides arborea?
Polygyra species

The mammoth, mastodon, and other vertebrated animals, no doubt, formed a part of the fauna of the Yarmouth Interglacial Stage in Illinois. The mastodon is known from four localities.

Mammut americanum

Henry County; Cambridge, in well 16 feet below the surface.

Johnson County; Bloomfield, in yellow clay, 3 feet below the surface.

Marion County; Sandoval, 12 feet below the surface.

Washington County; Beaucoup, 18 feet below the surface, under the yellow clay, in the older reddish clay.

Old soil deposits, some of them containing wood, are known from the following counties. These are apparently referable to the Yarmouth interval, as they underlie Illinoian drift.

[85] Leverett, *op. cit.*, p. 115.

[86] This is evidently the same list given by Udden in Proc. Iowa Acad. Sci., V, p. 103. *Polygyra* species is the only added species in Udden's list. The recent nomenclature is used. *Succinea luteola* is a southern species, and the identification is probably an error for *avara*, which is common in the loess.

Adams,[87] Carroll,[88] Cass,[89] Fulton,[90] Hancock,[91] Hamilton,[92] Iroquois,[93] Jackson,[94] Jersey,[95] Knox,[96] Marion,[97] Menard,[98] Macon,[99] Monroe,[100] Pike,[101] Perry,[102] Peoria,[103] Randolph,[104] Richmond,[105] St. Clair,[106] Sangamon,[107] Shelby.[108]

9. INDIANA

Strata apparently referable to the Yarmouth Interglacial interval are found in various parts of Indiana. Near South Milan, Ripley County, a section is reported showing the strata indicated below:[109]

1. Light colored clay soil	10-14 feet
2. Yellow clay with flint gravel and fossil corals (Illinoian)	12 "
3. Blue glacial clay (Illinoian)	12 "
4. Coarse yellow sand with recent shells and water (Yarmouth)	8 "
5. Blue clay, muck, containing roots and limbs of trees (Yarmouth)	8 "

These strata are in an old river valley, probably preglacial.

In Vermilion County[110] wells sunk in the prairie between Eugene and Perryville reach a mass of leaves, twigs and trunks of trees, locally known as "Noah's barn-yard." The deposit is soft, sticky, bluish clay, 6-10 feet thick, and overlaid by 60 feet of "alluvial sand." The deposit is believed to be referable to the Yarmouth horizon.

[87] Leverett, Illinois Glacial Lobe, p. 715.
[88] *Op. cit.*, p. 612.
[89] Worthen, Geol. Illinois, VIII, p. 16.
[90] *Op. cit.*, IV, pp. 91-92.
[91] Leverett, *op. cit.*, pp. 678, 684.
[92] Worthen, Geol. Ill., VI, p. 75.
[93] Leverett, *op. cit.*, p. 656.
[94] *Op. cit.*, p. 779.
[95] Worthen, Geol. Ill., III, p. 107.
[96] Leverett, Ill. Glacial Lobe, pp. 678, 684.
[97] *Op. cit.*, p. 759.
[98] *Op. cit.*, p. 710.
[99] Broadhead, Geol. Ill., VI, pp. 165, 192.
[100] Winchell, Proc. Amer. Assoc. Ad. Sci., XXIV, p. 48.
[101] Leverett, Ill. Glacial Lobe, p. 720.
[102] Worthen, Geol. Ill., III, p. 87.
[103] Worthen, *op. cit.*, V, p. 236.
[104] Worthen, *op. cit.*, III, p. 75.
[105] Worthen, *op. cit.*, VI, p. 45.
[106] Leverett, Ill. Glacial Lobe, pp. 763-764.
[107] Shaw and Savage, Tallula-Springfield Folio, No. 188, p. 7.
[108] Broadhead, Geol. Ill., VI, pp. 165, 192.
[109] Borden, Geol. Surv. Ind., VII, pp. 195-196.
[110] Bradley, *op. cit.*, I, p. 140.

Near Evansville, Vanderburg County, a coal shaft pierces the following deposits:[111]

Surface soil (loess)	9 feet	6 inches	
Blue clay (Illinoian terrace)	30 "	6	"
Gray sand (Illinoian terrace)	2 "	6	"
Blue mud, quicksand (Illinoian)	22 "	3	"
Gravel, sand, and shells (Yarmouth)	6 "	0	"
Fire clay and sand	28 "	3	"
Gravel and sand	1 "	0	"
Sandstone	2 "	0	"
Height of section	102 "	0	"

The mollusks from stratum 5 are listed below:

As listed	Modern name
Unio chunii	*Fusconaja chunii*
" between *lincecurii* and *plicatus*	*Crenodonta perplicata*?
" *asper*	*Quadrula asper*
" *obliquus*	*Pleurobema obliquum*
" *purpuratus*	*Proptera purpurata*
Trypanostoma unciale	*Pleurocera unciale*
" *canaliculatum*	" *canaliculatum*
" *alveare* v. *torquatum*	" *alveare*
Lioplax cyclostomatiformis v. *contorta*	*Lioplax cyclostomatiformis*
Melantho ponderosa	*Campeloma ponderosum*

The molluscan fauna indicated above is remarkable because many of the species at present are found at some distance from the Ohio River. The present range of the majority of the species is as shown below:

Chunii; Mississippi west to central Texas, north to Arkansas.
Asper; Streams flowing into the Gulf of Mexico from Alabama west to central Texas, and northward to the Verdigris River, Kansas.
Perplicatus; Alabama River drainage and streams flowing into the Gulf of Mexico west to central Texas, north to southern Kansas.
Purpuratus; Eastern Texas, north to Kansas, thru southern Missouri, western Tennessee, to the Alabama River drainage.
Pleurocera unciale and *P. alveare*: Tennessee and Alabama.
Lioplax cyclostomatiformis; Alabama and Georgia.

Only three species are at present living in the Ohio River. If the identifications were correctly made, these shells indicate a change of climate of large degree, fully as much as an average temperature addition of 10 or 15 degrees. The presence of the horse and tapir in deposits of equivalent age also indicate a warmer climate. The presence of the Alabama species also opens up the question of avenues of transportation, and probably strengthens the theory of

[111] Collett, *op. cit.*, VII, p. 270.

the ancient Appalachian River which included the Tennessee above Chattanooga added to the Coosa-Alabama River system.

In the bank of the Ohio River, near the mouth of Pigeon Creek, below Evansville,[112] deposits occur which contain the fauna indicated below:

Mollusca

Pleurocera canaliculatum
Campeloma ponderosum
Fragments of Unios

Mammalia

Megalonyx jeffersoni
Bison bison (probably an extinct species)
Odocoileus virginianus
Equus complicatus
Tapirus haysii (first listed as *T. terrestris*)
Canis indianensis (same as *C. dirus*)

Near Henderson, Kentucky, a section of the "Peoples Mine" shaft exhibited strata evidently referable to the interval under discussion.[113]

1. Yellow clay and sand	10 feet
2. Black, peaty soil	4 "
3. Blue clay	3 "
4. Yellow clay and quicksand, clay and sand, with boulders 1-6 inches in diameter and a great variety of subtropical fresh water mussels and univalves	10 "
5. Porus limestone	1 "
Height of section	28 feet

In the river bank near Henderson a deposit occurs 85 feet below the surface which is comparable to the stratum at Evansville. The bones of *Megalonyx jeffersoni* were associated with *Campeloma ponderosum*, *Pleurocera canaliculatum*, *Physa*, *Planorbis tricarinata* (probably intended for *bicarinata* = *antrosus*), *Planorbis lens* (= *exacuous* or *dilatatus*), *Cyclostoma* (= *Valvata*), and fragments of Unios. *Cyclas rivularis* is mentioned but no such species is known. The bone and shell bed was contained in a stratum of ferruginous sand underlaid by blue or dark ash-colored clay.[114]

Collett[115] reports *Megalonyx*, *Elephas americanus* and *Castoroides ohioensis* from black quicksand or cherty gravel in Vanderburg and adjoining counties. The strata near the river are in alluvial terraces older than Wisconsin time

[112] Leidy, Proc. Phil. Acad. Sci., VII, pp. 199-200, 1854; also 14th An. Rep. Dept., Geol. Nat. Res. Ind., part II, 1884. Hay (Geol. Iowa, XXIII, p. 108) refers the Pigeon Creek and Henderson deposits to the Sangamon interval. If the river terrace is of Illinoian age, the fauna beneath would belong to the Yarmouth interval. They are so considered here.

[113] Collett, Geol. Surv. Ind., 7th An. Rep., p. 271.

[114] Leidy, Smith. Contr. Knowl., VII, Art. V, pp. 7-8.

[115] *Op. cit.*

and referable to the Illinoian invasion. The fauna beneath this terrace deposit must therefore be pre-Illinoian or Yarmouth in age.

A number of mammals have been reported from strata apparently of Yarmouth age. Winchell[116] cites *Mastodon* remains in Clarke County, in the Township of Utica, at a depth of 30 feet, in gravel or altered drift. Also in high lands about Charleston and in other elevated positions about the town, pine and cedar wood in wells. Wylie[117] records *Elephas primigenius* from a deposit one mile southeast of Gosport, Owen County; bones were found in a bed of sand 8 feet below the surface, underlying blue clay, the latter Illinoian drift. Leidy[118] reports *Dicotyles (Mylohyus) nasutus* from a depth of 30-40 feet below the surface in Gibson County. While it is not possible to place this record without doubt in any horizon, the presumption is greatly in favor of its being pre-Illinoian and hence a member of the Yarmouth fauna. The mastodon is reported from Posey County, near the mouth of the Wabash River, in a well 60 feet beneath the surface.[119] This record is also probably pre-Illinoian.

What are thot to be pre-Illinoian soils occur in Pike and Gibson counties. A typical section from each county is shown below:[120]

S. W. of Petersburg, Pike County

Blue mud	61 feet
Logs of wood, lumps of coal, (lignite), etc	1 foot
Gravel	1 "
Soft clay (no pebbles reported)	35 feet
Sandstone	x

N. W. of Francisco, Gibson County

Dirt and sand	12 feet
"Ash loam"	4 "
Blue clay	60 "
Quicksand	30 "
Coal (lignite)	0 " 4 inches
Gravel with water	x

"About five miles west of Wheeling, which is outside the limits of the quadrangle, a clay with abundant pebbles of the type characterizing Illinoian drift was found overlying a true loess carrying common loess fossils, which in turn rested on an oxidized drift sheet."[121] The loess is probably of Yarmouth age, and the older drift may be of Kansan age.

[116] Proc. Amer. Assoc. Ad. Sci., XXIV, p. 50.
[117] Amer. Journ. Sci., (ii), XXVIII, p. 283.
[118] Proc. Phil. Acad. Sci., 1860, p. 416.
[119] Hay, An. Rep. Dep. Geol. Nat. Res. Ind., XXXVI, p. 711.
[120] Ditney Folio, U. S. Geol. Surv., No. 84, p. 3.
[121] *Op. cit.*, p. 3.

Deposits apparently referable to the Yarmouth horizon, altho a few of these may prove to be of Sangamon age, have been recorded as follows:

Vigo,[122] Bartholomew,[123] Warren,[124] Brown,[125] Jennings,[126] Vermilion,[127] Clay,[127] Knox,[128] Dubois,[129] Parke,[129] Ohio,[129] and Franklin[130] counties.

10. OHIO

References to the old soil and old forest beds of Ohio are very numerous. Many of these are indefinite and may refer to either the Yarmouth or the Sangamon intervals. In Montgomery County, near Germantown, a section passed thru two tills and penetrated a peat bed of considerable thickness. This is shown below:

Section on Twin Creek

1. Till (Wisconsin)	60-70 feet
2. Stratified sand and gravel (Sangamon)	10 "
3. Till (Illinoian)	15-25 "
4. Peat in saucer shaped depression (Yarmouth)	12-20 "

The upper layers of peat (No. 4) contained the species of plants indicated below:[131]

Sphagnum moss
Grasses
Sedges
Juniperus virginianus
Coniferous wood

Three species of mammals are reported.

Elephas
Mastodon americanus
Castoroides ohioensis

It is said that scarcely a square mile in Montgomery County is without this peat stratum.

It is believed that records of the old forest bed in southern Ohio should be referred to the Yarmouth interval, as they underlie deposits apparently refer-

[122] Scovell, Geol. Ind., XXI, p. 557.
[123] Elrod, *op. cit.*, XI, p. 163.
[124] Collett, *op. cit.*, V, p. 195.
[125] *Op. cit.*, VI, p. 99.
[126] Borden, Geol. Ind., 7th An. Rep., pp. 171-174.
[127] Winchell, Proc. Amer. Assoc. Ad. Sci., XXIV, p. 49.
[128] *Op. cit.*, p. 51.
[129] *Op. cit.*, p. 50.
[130] Bradley, Geol. Ind., I, p. 185.
[131] Amer. Journ. Sci., (ii), L, pp. 54-57; Newberry, Geol. Ohio, II, p. 31.

able to the Illinoian drift. A typical section in Clermont County is shown below:

Well Section at Mount Oreb, near Bethel[132]

1.	Yellow clay, pebbly	14 feet
2.	Sand and gravel	6 "
3.	Blue till (Illinoian drift)	20 "
4.	Black mucky clay	15 "
5.	Sand	3 "
6.	Alternations of bluish clay and black muck extending to the limestone	10 "
	Height of section	68 "

Leverett doubtfully refers to No. 4 as preglacial, but it would seem to more nearly fill conditions for the Yarmouth interval. Orton, who first published the above section,[133] remarks that all wells dug pass thru this buried soil. It would appear to be of wide extent in this portion of Ohio, and has been specifically noted in Hamilton County,[134] where stumps bear the mark of the huge *Castoroides*, which was associated with the mastodon and the mammoth; near Hyattville, Delaware County, an old soil is found beneath blue till. This section is noted below:[135]

5.	Loose, fresh yellow till	6–8 feet
4.	Blue, hard jointed till (apparently old-Illinoian)	6 "
3.	Stratified sand, much weathered (thickness variable)	2 "

At Paris,[136] Champaign County, on summit between Mad River and the Great Miami Valley, a well section reached large pieces of wood (red cedar) and fragments of mussel shells in gravel at 400 feet. This section is believed to be in the ancient channel of the Miami River, and the deposit may represent the Yarmouth interval. Near New Burlington, Clinton County, wood, leaves, and sticks have been found in blue clay at from 15 to 40 feet below the surface.[137]

In Brush Creek, Adams County,[138] the horns of an extinct ox (*Bison latifrons*) were found 18 feet below the surface in a gravel deposit, lying on the Cincinatti group of the Ordovician. Many years ago Whittlesey[139] reported the remains of a horse from fissures in clay seams of limestone, near Columbus, Franklin County. This may be referable to the Yarmouth interval or it may be of Sangamon age. Many records from Ohio cannot be satisfactorily placed

[132] Leverett, Mon. 41, p. 273.
[133] Geol. Ohio, I, p. 443.
[134] *Op. cit.*, pp. 429, 432.
[135] Geol. Surv. Ohio, Bull., 14, p. 61.
[136] Orton, Geol. Ohio, VI, p. 277.
[137] Whittlesey, Amer. Journ. Sci., (ii) V, pp. 213-214, 1848.
[138] Smith, Journ. Cin. Soc. N. H., X, pp. 19-24; Amer. Journ. Sci., (iii), X, p. 386, 1875.
[139] Amer. Journ. Sci., (ii), V, p. 215, 1848.

on account of the lack of stratigraphical data. To this class belong many of the records of Winchell, Whittlesey, and other early Ohio geologists.

11. CANADA

The Yarmouth Interglacial interval is apparently represented in southern British America, west of the 100th meridian. This area is covered by the Wisconsin drift sheet, which rests upon the Kansan drift sheet. Interglacial deposits between these sheets are probably to be referred to the Yarmouth interval, tho some may represent other intervals between these two stages. Strata immediately overlying the lower (Kansan) drift are probably correctly referred to the Yarmouth interval.

On the Rolling River, a tributary of Swan River, west of the 101st meridian, in Manitoba, a section was observed by Mr. J. B. Tyrell, which is reproduced below:[140]

1. Stratified gravel	10?	feet	0	inches
2. Unstratified till with striated boulders	22	"	0	"
3. Stratified sandy clay, becoming a pure laminated clay at the bottom, where it contains many fresh water shells and diatoms	6	"	0	"
4. Stratified gray sandy clay	20	"	0	"
5. Slightly sandy stratified clay, colored dark brown with bituminous matter, and containing a few small bivalves	1	"	10	"
6. Plastic clay	5	"	0	"
7. Coarse stratified sand	12	"	0	"
8. Covered to water	12	"	0	"
Height of section	88	"	10	"

Eight species of mollusks were obtained from the deposit No. 3.

Lymnaea catascopium (short spired variety)
Valvata tricarinata
" " (keelless variety, = *ecarinata*?)
Amnicola limosa porata?
Planorbis bicarinatus (= *antrosus*)
" *parvus?*
Pisidium abditum
Sphaerium striatinum

With the shells also occured a number of diatoms as well as several higher plants, which are enumerated below:

Elodea canadensis
Taxus canadensis
Vallisneria spiralis

At Churchbridge, on the Manitoba and Northwestern Railway, a well showed the following section:[141]

1. Sandy loam	8 feet
2. Clay with gravel and small stones	12 "
3. Gray sand	2 "

[140] Can. Geol. Surv., 1890-91, p. 116E, 217E, 1892.
[141] *Op. cit.*, p. 142 E.

4. Rocks and clay, about all rocks	3 feet
5. Blue clay and small stones	7 "
6. Gray sand	1 "
7. Soft blue clay with layers of sand one inch thick about every two feet, no pebbles or boulders	234 "
Height of section	267 "

In the bed number 7, at a depth of 200 feet, a piece of wood was found which Prof. Penhallow has named *Larix churchbridgensis*. The same species has been reported from southern Manitoba in postglacial deposits.[142]

In the vicinity of the Bow and Belly rivers, between 110 and 115 degrees west longitude, and just north of the United States boundary, a general section is found to be as follows:[143]

Stratified sands, gravels and silts
Upper boulder clay
Interglacial deposit with peat
Lower boulder clay
Quartzite shingle and associated beds.

At Wolf Island, Belly River, a section exhibited 173 feet, as noted below:

Correlation	Character	Depth
Wisconsin till	Boulder clay	100 feet
Yarmouth interval	Interglacial deposit with peat	8 "
Kansan till	Boulder clay	15 "
Aftonian interval	Yellowish & brownish-yellow sands	15 "
	Purplish-gray clay	4 "
	Yellow sands	6 "
Nebraskan till	Quartzite shingle	15 "
	Cretaceus shales and sandstones	10 "
	Height of section	173 feet

The deposits beneath the lower boulder clay are probably referable to the Aftonian interval and the Nebraskan drift. No organic remains are reported.

The *Ficus* described by Hollick,[143a] and referred to the Aftonian on a previous page, may be of Yarmouth age. No age is assigned to the deposit by Hollick nor is the species named other than to genus.

12. ALASKA

Two glacial stages have been observed in Alaska by Capps,[144] an earlier one separated from a later by an interglacial interval of long duration, the

[142] *Op. cit.*, p. 143 E.
[143] Dawson, Geol. Surv. Can., 1882-84, p. 140 C.
[143a] Bull. Geol. Soc. Amer., XXVI, p. 159, 1915.
[144] Journ. Geol., XXIII, pp. 748-756, 1915.

interglacial deposits being covered in places by a lava flow and this by a later ice sheet, the Wisconsin. No correlation is made of this interglacial interval with the intervals of the Mississippi Valley, but it might have been coeval with the Yarmouth interval, which was of long duration.

III. SYSTEMATIC CATALOG OF THE BIOTA OF THE YARMOUTH INTERGLACIAL INTERVAL

PLANTS

BRYOPHYTA

Sphagnaceae

Sphagnum species

Hypnacae

Drepanocladus aduncus(L.) Warnst.

SPERMATOPHYTA

Taxaceae

Taxus canadensis Marsh

Pinaceae

Pinus species
Juniperus virginiana Linn.
Picea canadensis (Mill.) BSP. (?)
Picea species
Larix laricina (DuRoi) Kch. =*americana*
" *churchbridgensis* Penhallow

Monocotyledoneae

Hydrocharitaceae

Elodea canadensis Michx.
Vallisneria spiralis Linn.

Gramineae

Species indet.

Cyperaceae

Species indet.

Dicotyledoneae

Boraginaceae

Lithospermum (seeds)

ANIMALS

Mollusca

PELECYPODA

Unionidae

Fusconaja chunii (Lea)
" *rubiginosa* (Lea)
Crenodonta perplicata (Conrad) ?
" *undulata* (Barnes)
Pleurobema obliquum (Lam.)
Proptera purpurata (Lam.)
Quadrula asper (Lea)
" *pustulosa* (Lea)

	SPHAERIIDAE
Sphaerium sulcatum (Lam.)	*Pisidium medianum* Sterki
" *striatinum* (Lam.)	" *abditum* (Hald.)
Musculium transversum (Say).	" *compressum* (Prime)
Pisidium variable Prime.	
	GASTROPODA
	HELICINIDAE
Helicina occulta Lamarck.	
	VALVATIDAE
Valvata tricarinata Say	*Valvata sincera* Say ?
" *lewisii* Currier	
	AMNICOLIDAE
Amnicola limosa porata (Say)	*Pomatiopsis lapidaria* (Say)
	VIVIPARIDAE
Campeloma ponderosum (Say)	*Lioplax cyclostomatiformis* (Lea)
" *subsolidum* (Anthony)	
	PLEUROCERIDAE
Pleurocera canaliculatum (Say)	*Pleurocera unciale* (Hald.)
" *alveare* (Conrad)	" species.
	PHYSIDAE
Physa gyrina Say	*Physa* species
	PLANORBIDAE
Planorbis antrosus Conrad	*Planorbis parvus* Say
" *antrosus striatus* Baker	" *deflectus* Say
" *trivolvis* Say	" *exacuous* Say
	LYMNAEIDAE
Galba caperata (Say)	*Galba palustris* (Müller)
" *obrussa* (Say)	" *catascopium* (Say)
" *humilis modicella* (Say)	*Pseudosuccinea columella* (Say)
	AURICULIDAE
Carychium exiguum (Say)	*Carychium exile* H.C. Lea.
	SUCCINEIDAE
Succinea ovalis Say	*Succinea grosvenorii* Lea
" *avara* Say	" *retusa* Lea
	VALLONIIDAE
Vallonia gracilicosta Reinh.	*Vallonia pulchella* (Müller)
" *parvula* Sterki	
	COCHLICOPIDAE
Cochlicopa lubrica (Müller)	
	PUPILLIDAE
Bifidaria armifera (Say)	*Pupilla blandi* (Morse)
" *pentodon* (Say) = *curvidens* Say	*Vertigo milium* (Gould)[144a]

[144a] *Vide* Sterki.

Bifidaria contracta (Say)
" *tappaniana* (C.B. Adams)
=*pentodon* Authors.
" *holzingeri* (Sterki)
" *procera* (Gould)
Pupilla muscorum (Linn.)
Vertigo ovata Say
" *bollesiana* (Morse)
Leucochila fallax (Say)
Strobilops labyrinthica (Say)
" *virgo* (Pislbry)

ENDODONTIDAE

Sphyradium edentulum alticola (Ingersoll)
Helicodiscus parallelus (Say)
Pyramidula cronkhitei anthonyi Pilsbry
" *perspectiva* (Say)
Pyramidula alternata (Say)
" *shimekii* (Pilsbry)
" *solitaria* (Say)
Oreohelix iowensis Pilsbry

ZONITIDAE

Zonitoides arborea (Say)
" *minuscula* (Binney)
Euconulus fulvus (Müller)
Vitrea hammonis (Ström)
" *indentata* (Say)
Gastrodonta ligera (Say)

HELICIDAE

Polygyra hirsuta (Say)
" *monodon* (Rackett)=*leai* (Ward)
" *clausa* (Say)
" *fraterna* (Say)
" *inflecta* (Say)
" *appressa* (Say)
Polygyra thyroides (Say)
" *multilineata* (Say)
" *profunda* (Say)
" *albolabris* (Say)
" *elevata?* (Say)
" *zaleta* (Binney)

ARTHROPODA

Species indet

COLEOPTERA

Species indet.

VERTEBRATA

PISCES

SALOMONIDÆ

Cristivomer namycush (Walbaum)

AVES

Genus et species indet.

MAMMALIA

MEGATHERIIDAE

Megalonyx jeffersoni Desmarest

EQUIDAE

Equus complicatus Leidy

TAPIRIDAE

Tapirus haysii Leidy

TAYASSUIDAE

Mylohyus nasutus (Leidy)

CERVIDAE

Odocoileus virginianus (Zimm.)
Rangifer, cf. *muscatinensis* Leidy
Rangifer species
Cervalces roosvelti Hay

BOVIDAE

Bison latifrons (Harlan)
" *occidentalis* Lucas
Symbos cavifrons (Leidy)

ELEPANTIDAE

Elephas primigenius Blum.
" *columbi* Falconer
Mammut americanum (Kerr)

CASTOROIDIDAE

Castoroides ohioensis Foster

LEPORIDAE

Sylvilagus floridanus (Allen)

MUSTELIDAE

Mephitis mephitica (Shaw)

CANIDAE

Canis dirus Leidy

IV. SUMMARY

The deposits of the Yarmouth Interglacial interval are known to extend from Nebraska and South Dakota eastward to southeastern Ohio, including Illinois and Indiana; they extend south to the Missouri River in Missouri, and to northern Kentucky; to the north they are found in Minnesota and southern Manitoba, Saskatchewan, and Alberta. That the interval was of long duration is believed by Leverett,[145] who states that the thickness of peat and associated deposits is impressive evidence of an interglacial interval of considerable length. The extent of the weathered zone is still greater proof. Additional evidence of the long duration of this interval (in Iowa) is furnished by Kay,[145a] who cites the great amount of weathering of the Kansan drift "which produced a gumbo (gumbotil) over 20 feet in thickness, the diastrophic elevation of 150 to 200 feet, and the mature topography which was developed by erosion after the diastrophism and apparently, in the main, before the close of the Yarmouth epoch."

Osborn[146] believes that the Yarmouth was the longest interglacial interval and says of its climate: "It would appear that the Second Interglacial Yarmouth Stage was of greater duration than the entire interval between the Third Glacial and the present time. In the course of this long warm Second Interglacial Stage the climate again moderated, becoming slightly warmer than the climate of today. The climate immediately following the retreat of the ice was cool and moist, then followed a long warm stage, but this stage was finally

[145] Illinois Glacial Lobe, p. 43.
[145a] Science, N. S., XLIII, p. 398, 191 6.
[146] Men of the Stone Age, p. 269.

succeeded by a period of aridity both in Europe and America in which the first loess deposit occurred."

That the fauna and flora advanced into the territory laid bare by the recession of the Kansan ice is attested by the wide-spread character of the discovered remains of animals and plants, 124 species being rather definitely recorded; 12 plants, 20 vertebrates, and 92 mollusks. Of the plants, all are now living and none is peculiar. The Spermatophytes are the leading type, the Pinaceae furnishing the larger number of species. The Mollusca are largely represented, 92 species being recorded, 2 of which are extinct, tho having living representatives in the drier portions of the southwest; 40 species are aquatic and 52 species are terrestrial. Streams and ponds, as well as rivers, must therefore have been numerous, and moist woodlands as well as drier uplands probably were present:

As far as the plants and mollusks are concerned the life of the Yarmouth Interglacial interval was very little, if any, different from that of today. The vertebrates, however, tell a different story, for of 20 species represented, at least 14 or 70 per cent are extinct. Giant sloths, horses, peccaries, tapirs, elephants, deer, bison, giant beavers, hares, skunks, and wolves roamed about the country and formed a vertebrate fauna quite different from that of today. The insects, of which only a few wings of beetles are known, will probably tell a similar story when a sufficient number have been discovered and classified.

The presence of the peccary, giant sloth and tapir point to a climate considerably warmer than the present. Other mammals, as the deer, rabbit, skunk, and bison suggest a climate not warmer than that of the present time. The pine, tamarack, and juniper suggest a cooler climate. It is probable that during this interglacial period there was a succession of climates as the ice sheet waned and waxed again—cold, temperate, warm; warm, temperate, cold. That a portion of the country was dry is attested by the loess deposits and their fossils, all pointing to periods of prolonged dryness. The fauna of the loess is discussed at greater length in Chapter X.

CHAPTER IX.

THE ILLINOIAN ICE INVASION AND THE SANGAMON INTERGLACIAL INTERVAL

I. The Illinoian Ice Invasion

"The typical formation of this stage was a sheet of till occupying the surface in the southern and western portions of Illinois, and running back under the later formations to the northeast toward the Labradorean center of radiation. Its surface exposure is traceable northerly into Wisconsin and easterly into Indiana and Ohio, but it is not identified with any confidence farther east, where the margin seems to have fallen back, and to have been overridden by the ice of the Wisconsin epoch. The identification of the Illinoian drift in the Keewatin area is yet an open question. Like the Kansan drift, the Illinoian is made up of clayey till, without marked association with assorted drift in most regions. There is appreciably more assortment of the material, however, than in the Kansan drift. There are tracts of kames in some sections, notably a belt running southwest from Tower Hill, Illinois, to the margin of the drift. The original surface was generally plane, and only a limited tendency to ridging in the fasion of terminal moraines has been found. The west edge of the Illinoian ice-lobe crossed the present course of the Mississippi between Rock Island and Fort Madison, and pushed out into Iowa a score of miles, forcing the river in front of it. Previously the Kansan lobe had forced the Mississippi east of its present course, if indeed it did not already have a course east of its present one before the Kansan ice appeared. Efforts to trace out the early courses of the Mississippi under the thick mantle of drift in Illinois have not been entirely successful "[1] .

II. The Sangamon Interglacial Interval

A. Sangamon soil and weathered zone; typical exposures

"Between the disappearance of the Illinoian ice sheet and the deposition of the Iowan till and loess there occurred an interval of deglaciation about as marked as that between the Kansan and Illinoian stages of glaciation, a period marked by leaching and oxidation of the Illinoian drift, of peat and soil accumulation, and of erosion. This interval was long since brought to notice by Prof. A. H. Worthen in his report on Sangamon County, Illinois. For this reason,

[1] Chamberlin and Salisbury, Geology, III, p. 391.

and because of the conspicuous development in the Sangamon drainage basin, it seems appropriate to name it the Sangamon Interglacial Stage."[2]

A typical generalized section of the strata in Sangamon County is given by Leverett, after Worthen, and is reproduced below:

Soil	1-2 feet
Yellow clay (Iowan loess)	3 "
Whitish (gray?) jointed clay, with shells (Illinoian loess)	5-8 "
Black muck with fragments of wood (Sangamon soil)	3-8 "
Bluish colored boulder clay (Illinoian drift)	8-10 "
Gray hardpan, very hard (Illinoian)	2 "
Soft blue clay, without boulders	20-40 "

This interval is widespread in Illinois, but is not always represented by muck beds. Sometimes it is represented by a leached and somewhat reddish deposit which has been called the 'ferretto' zone by Dr. H. F. Bain.[3] In some areas there is an alternation of sand with peaty beds, this phase being restricted, apparently, to the borders of valleys where stream action has been more or less active, intermittently. The blue loess is also to be included in the Sangamon interval, and is to be separated from the upper yellow or Iowan loess. The Sangamon is considered first in those states in which it covers the exposed Illinoian drift, and later in those states to the north and northeast in which this drift sheet is covered by the Wisconsin till.

B. DISTRIBUTION OF THE SANGAMON BIOTA

1. IOWA

As has already been stated, the Illinoian ice sheet invaded Iowa, pushing the Mississippi River westward for several miles. Illinoian drift is found near Fort Madison northward to near the northern boundary of Scott County. In this area a number of deposits occur which are referable to the Sangamon interval. In Des Moines County, near Burlington, a section exposes the following strata:[4]

1. Brownish yellow clay free from gravel, grading into No. 2 (Iowan loess)	5 feet
2. Typical ashen compact loess (Illinoian)	8 "
3. Till with abundance of gravel and pebbles (Illinoian)	20 "
Height of section	33 feet

[2] Leverett, Illinois Glacial Lobe, p. 125; Proc. Iowa Acad. Sci., V, p. 71; Worthen, Geol. Ill., V, pp. 306-319.

[3] Proc. Iowa Acad. Sci., V, p. 91.

[4] Keyes, Iowa Geol. Surv., III, p. 156.

Number 2, referable to the Sangamon or Illinoian loess, contained six species of mollusks.

Pyramidula perspectiva	*Succinea obliqua*
" *cronkhitei anthonyi*	*Helicina occulta*
Pupilla muscorum	*Galba obrussa (=desidiosa)*

Leverett[5] also lists a number of species from this locality, these being:

Succinea obliqua	*Oreohelix iowensis*
" *lineata (=grosvenorii)*	*Pyramidula cronkhitei anthonyi*
Helicina occulta	" *perspectiva*

In Louisa County, at Grandview, from the bottom of a well 12 feet deep, four species of mollusks were collected.[6]

Succinea avara	*Galba caperata*
" *grosvenorii*	" *humilis modicella*

In the same county, Udden[7] states that the Sangamon old soil is especially pronounced in the east bluffs along the Iowa River, northeast of Wapello. In the bluff of the Mississippi River, where the Muscatine North and South R. R. has made a cut, the Sangamon soil or peat is partly replaced by gymnospermous wood. In Sweetland Township, Muscatine County, (SW¼ Sect. 12, T. 77 N, R. 1 W) elephant bones were observed in a peat deposit containing gymnospermous wood.[8] The elytra of beetles have also been found, and at two other points the remains of the elephant have been observed. The succession of strata noted below is exhibited in this region:

Loess
Sangamon soil
Illinoian till
Buchanan gravel and Yarmouth soil
Kansan till
Aftonian
Nebraskan till

From the Sangamon soil in the bed of Otter Creek, near Morning Sun, (NW¼ Sect. 25, T. 73 N, R. 4 W) several bones of a mastodon were obtained.[9] An elephant tooth was also found in a well near a tributary of Indian Creek, which may have come from the same horizon.[8] The antler of a deer (probably extinct) was reported by Udden from NW¼ Sect. 14, T. 74 N, R. 3 W.

[5] Illinois Glacial Lobe, p. 169.
[6] Udden, Geol. Iowa, XI, p. 112.
[7] Geol. Iowa, XI, pp. 101-111.
[8] *Op. cit.*, p. 110.
[9] Udden, Iowa Geol. Surv., IX, p. 350.

At Davenport, in Scott County, Leverett records the presence of a post-Illinoian loess. Near the base of the loess at Division Street, eight species of mollusks were secured by Prof. Udden:[10]

Helicina occulta	*Bifidaria pentodon*
Succinea avara	*Galba palustris*
Sphyradium edentulum alticola	" *caperata*
Pyramidula cronkhitei anthonyi	*Sphaerium*-fragment of valve

Udden's first list differs somewhat (*op. cit.*, p. 168) and may have been based on specimens from a higher position in the loess.

Succinea avara	*Pyramidula cronkhitei anthonyi*
" *grosvenorii*	*Helicodiscus parallelus*
" *luteola*	*Helicina occulta*
Cochlicopa lubrica	*Sphyradium edentulum alticola*

In a cut along the Chicago, Rock Island and Pacific Railroad, west of Davenport, the tusk, teeth, and other bones of *Elephas primigenius* were found in a bed of bluish loess (post-Illinoian) 3-5 feet thick which lay just above a bed of brown peat (Sangamon soil) 1 foot in thickness. This deposit has been thot to be Aftonian, but seems clearly post-Illinoian.[10a]

Mammoth bones, apparently referable to the Sangamon, have been found at Big Rock and Blue Grass, Scott County. The latter was buried 10 feet below the surface, embedded in yellow clay.[11]

At Muscatine, Muscatine County, fossiliferous deposits occur which are referable to the Sangamon interval. McGee[12] lists the following fauna:

Fusconaja ebena	*Pupilla blandi*
Nephronajas ligamentina	*Bifidaria corticaria*
Eurynia recta	" *pentodon*
Arcidens confragosus	*Sphyradium edentulum alticola* (=*simplex*)
Campeloma subsolidum	*Helicodiscus parallelus* (=*lineata*)
Helicina occulta	*Pyramidula cronkhitei anthonyi* (=*striatella*)
Galba humilis modicella	*Oreohelix iowensis* (=*'cuperi'*=*cooperi*)
Succinea ovalis	*Euconulus fulvus*
" *avara*	*Vallonia gracilicosta* (=*pulchella*)
Pupilla muscorum	

The four naiades as well as the *Campeloma* listed above, probably came from a fluviatile stratum beneath the true loess, probably formed at a time when the Mississippi was at a much higher level than at present.

[10] Illinois Glacial Lobe, p. 173.

[10a] Pratt, Proc. Daven. Acad. Sci., I, p. 96; Norton, Iowa Geol. Surv., IX, p. 482; Shimek, *op. cit.*, XX, p. 376.

[11] Anderson, Augustana Library Pub., No. 5, p. 35.

[12] 11th An. Rep. U. S. Geol. Surv., p. 471, after Witter. The modern nomenclature is here used.

A caribou (*Rangifer muscatinensis*) was found by Mr. Witter in a deposit thot to be loess.[13] Shimek (vide Hay, Geol. Iowa, XXIII, page 34) states that the bones were in a deposit bearing the same relation to the Illinoian drift that the Loveland bears to the Kansan drift, hence preceding the formation of the post-Illinoian loess. A fragment of an antler of a caribou was also said to have been found by Prof. Witter, in the loess at Neibert's brickyard, near Woodlawn and Orange streets, Muscatine.

A tooth of *Mammut americanum* was secured from the bank of Mad Creek, about a mile from its point of entrance to the Mississippi River. The tooth was found about 10 feet beneath the surface of the bluff in a bed of gravel. The deposit appears referable to the Sangamon.[14]

2. ILLINOIS

The Sangamon horizon is widely distributed in southern, western and northwestern Illinois, and old soil or weathered strata have been found in almost every county. In northwestern Illinois, the Iowan was at one time thot to overlie the Illinoian drift,[15] but later investigations[16] have shown that the older drift is all referable to the Illinoian drift sheet. A typical section showing post-Illinoian deposits is afforded by a coal shaft at Ashland, near the line of Sangamon and Cass Counties.

Black soil	1½ feet
Loess of yellow color (Iowan loess)	9 "
Loess of blue color (Illinoian loess)	2 "
Peat and black sandy slush (Sangamon)	22 "
Bluish gummy clay	20 "
Yellow till (Illinoian)	30 "
Height of section	84½ feet

a. *Deposits of Fluviatile Origin*

Five miles south of Milan, Rock Island County, a deposit occurs at the base of the loess in the bluff of Mill Creek. The fauna is almost exclusively aquatic.[17]

Succinea avara	*Planorbis parvus*
Lymnæa stagnalis appressa? (fragment)	*Valvata tricarinata*
Galba reflexa	" *sincera*
Planorbis albus	*Pisidium* species (fragments)

[13] Leidy, Amer. Journ. Sci., (iii), XVII, p. 410; Hay, Geol. Iowa, XXIII, pp. 34, 279.
[14] Witter, Proc. Iowa Acad. Sci., I, part 2, p. 67; Udden, Iowa Geol. Surv., IX, p. 352.
[15] Leverett, Illinois Glacial Lobe, Chapter VII.
[16] Alden, Journ. Geol., XVII, p. 694.
[17] Leverett, Illinois Glacial Lobe, p. 174.

b. *Old Soil Horizons*

Near Danville Junction, Vermilion County, the subjoined section was exposed in a well boring.[18]

Yellow till and gravel	20 feet
Blue till	15 "
Hardpan	30 "
Blue till	15 "
Sandy loam	10 "
Clay, sand and gravel	50 "
Muck bed with wood	8 "
Tough blue clay	25 "
Sand and gravel	2 "
Coal measures	x

The muck and wood appear to overlie the Illinoian drift and hence may be referable to the Sangamon interval.

Organic remains have been found in a ravine in Richland Creek, Woodford County (sect. 21, T 28, R. 2 W.), the section being interpreted as follows:[19]

1. Soil and yellow clay	50-60 feet	(Wisconsin)
2. Purplish clay or hardpan		
3. Blue sandy clay, containing fresh water shells	6 feet	(Sangamon)
4. Rotten drift wood and peaty matter	3½ "	
5. Blue clay	3-4 "	
6. Drift wood and peaty matter	5-6 "	
7. Blue clay	x "	(Illinoian)

No. 3 of the section contained *Lymnæa* and *Succinea*, and from No. 4 was obtained American white birch, black spruce, American tamarack and one variety of cedar. No. 6 contained American tamarack.

In Tazewell County,[20] at Delavan, the following section has been noted:

Yellow till (Wisconsin)	15 feet
Blue till (Wisconsin)	60 "
Muck and wood (Sangamon)	6 "
Green mucky clay (Sangamon)	8 "
Gray sandy till (Illinoian)	30 "
Gray sand (Illinoian)	122 "
Height of section	241 "

[18] Leverett, Illinois Glacial Lobe, p. 699.
[19] Green, Geol. Ill., IV, p. 336.
[20] Leverett, Illinois Glacial Lobe, p. 691.

Near Cooper a bed of muck was found between tills at a depth of 150 feet. In Champaign County,[21] at Mahomet, a similar section occurs showing this interval.

Gravel	7 feet
Pebbleless clay	3 "
Brown and gray till	32 "
Black muck	2 "
Hard till	58 "
Height of section	100 "

The black muck or peat deposit near Mahomet contains a beetle fauna of 10 species which has recently been studied by Wickham.[21a] The section from which the beetles came has been studied by Dr. T. E. Savage who refers the deposit to the Sangamon interval; it lies just above the Illinoian till and is separated from the Wisconsin till by a slight development of loess-like silt. Writing of the climate of the Sangamon, as indicated by the beetles, Wickham says: "I think we are quite justified in assuming that conditions were, at any rate, more rigorous than in southern Illinois at present. Probably they were at least as severe as in Ontario at the date of formation of the Scarborough beds." Four families and seven genera are represented by the ten species.

Carabidae
Carabus meander sangamon
Patrobus henslowi
Platynus pleistocenicus
" *subgelidus*
Chlaenius plicitipennis

Dytiscidae
Agabus savagei
" *praelugens*
Staphylinidae
Olophrum interglaciale
Chrysomelidae
Donacia styrioides

Comparison with the beetles of the Toronto beds at Scarborough indicate that none are identical as to species. It is probable that many peat deposits of interglacial age contain the remains of insect life, which will be of great value for comparison with these deposits already studied, when they have been given the same careful scrutiny.

In Mercer County (Sect. 9, T. 13, R. 4) in the bluff bordering Pope Creek, heavy beds of sandy marl occur, which contain some mollusks (*Lymnæa* and *Succinea*).[22] These beds apparently underlie Illinoian loess. In Boone County,[23] near Irene, a black soil is found separating Iowan from Illinoian till and containing molluscan shells.

Identifiable plants referable to the Sangamon appear to be rarely recorded from Illinois. At Bloomington the two species noted below were recognized

[21] *Op. cit.*, p. 703.
[21a] Amer. Journ. Sci., iv, XLIV, pp. 137-145, 1917.
[22] Green, Geol. Ill., IV, p. 302.
[23] Leverett, *op. cit.*, p. 375.

by Penhallow from material obtained at depths of 100 and 107 feet below the surface at the base of the Wisconsin drift.[24]

Picea canadensis (=*alba*) *Taxus minor* (=*baccata*)

In Sangamon County[25] a section in a well (NE ¼ Sect. 36, T. 18, R. 6, W.) showed the following strata:

Soil, black	3 feet
Clay, yellowish, fine grained (loess)	9 "
Soil, black, with pieces of wood (Sangamon)	4 "
Clay, yellow (Illinoian drift)	5 "
Boulder clay, blue, compact, with some quicksand (Illinoian drift)	10 "
Height of section	31 feet

The Sangamon soil overlies the drift in many places in this county, and includes logs and branches of trees. Mucky soil is reported by Leverett from beneath Wisconsin drift in Moultrie,[26] LaSalle,[27] and under 160 feet of Wisconsin till at Barringon, Lake County.[28] In the Fox River Valley the Wisconsin is underlaid by a thick bed of peat which overlies the Illinoian drift.[29] The Sangamon soil horizon has been definitely recorded from the following counties in Illinois:

McLean,[30] Henry,[31] Logan,[32] Edgar,[33] Greene,[34] Carroll,[35] Peoria,[36] Tazewell,[36] Sangamon,[37] Christian,[38] Menard,[39], Cumberland,[40] Coles,[40] Shelby,[40], Cass,[40] Knox,[40] LaSalle,[41] Iroquois,[41] Vermilion,[41] Champaign,[41] Ford,[41] Livingston,[41] McHenry,[41] Kane,[41] Clark.[42]

[24] Bull. Geol. Soc. Amer., I, p. 333.
[25] Shaw and Savage, Tallula-Springfield Folio, U. S. G. S., No. 188, p. 8.
[26] Illinois Glacial Lobe, p. 730.
[27] *Op. cit.*, pp. 636-641.
[28] *Op. cit.*, p. 581.
[29] B. W. Thomas, personal communication.
[30] Leverett, Illinois Glacial Lobe, p. 694.
[31] *Op. cit.*, p. 624.
[32] *Op. cit.*, p. 709.
[33] *Op. cit.*, p. 732.
[34] *Op. cit.*, p. 745.
[35] Leverett, Illinois Glacial Lobe, p. 612.
[36] Udden, Bull. 506, U. S. G. S., p. 56.
[37] Leverett, Proc. Iowa Acad. Sci., V, p. 76.
[38] Worthen, Geol. Ill., VIII, p. 15.
[39] *Op. cit.*, p. 16.
[40] Leverett, Proc. Iowa Acad. Sci., V, p. 78.
[41] Leverett, Proc. A. A. A. Sci., XXXVII, pp. 183-184.
[42] Leverett, Illinois Glacial Lobe, p. 733.

The following records have been referred to the Peorian by Leverett, but in the light of present evidence they would seem to be referable to the Sangamon interval:

Kankakee County;[43] old soil beneath blue till.

Iroquois County;[44] till underlaid at many points by a black soil and by beds of peat and shell marl; old soil 60-80 feet below the surface.

Woodford County;[45] Metamora, till 140, muck and sand 15, till 115 feet.

Douglass County;[46] near Areola, swampy muck below blue till at about 50 feet, harder till beneath.

Edgar County.[47]

McHenry County.[48]

Kane County;[49] at Elgin shoe factory, old soil at 118 and 113 feet; also at 111 and 114 feet; near St. Charles[50] old soils at 72 to 78 feet and 195-200 feet.[51]

DeKalb County;[52] several instances of an old soil below the Wisconsin.

Lee County;[53] old soil beneath 78-100 feet of drift.

Kendall County;[54] near Plano, old soil containing grass leaves beneath till at depth of 25 feet. Near Melbrook, old soil with wood at 160 feet.

Dewitt County;[55] a muck bed beneath 80 feet of till, underlaid by green clay, apparently a swamp subsoil.

Cook County; an old till was encountered in the Chicago drainage canal east of Summit (Leverett).

Many buried soils occur at different depths, and these have been referred by Leverett to both the Sangamon and the Peorian intervals. Such occur in Kane, DeKalb, LaSalle, Bureau, McLean, Lee and other adjacent counties.[56] These soils occur at depths of from 40-50 to 180-200 feet. In Iroquois County a soil horizon occurs at the base of the soft Wisconsin till, while another is encountered in the harder, Illinoian till.

[43] Leverett, Illinois Glacial Lobe, p. 654.
[44] *Op. cit.*, p. 655.
[45] *Op. cit.*, p. 672.
[46] *Op. cit.*, p. 731.
[47] *Op. cit.*, p. 732.
[48] *Op. cit.*, p. 577.
[49] *Op. cit.*, p. 595.
[50] *Op. cit.*, p. 597.
[51] This soil is evidently pre-Illinoian or Yarmouth.
[52] Leverett, Illinois Glacial Lobe, p. 600.
[53] *Op. cit.*, p. 610.
[54] *Op. cit.*, p. 644.
[55] *Op. cit.*, p. 707.
[56] Illinois Glacial Lobe, pp. 262-266.

In northeastern Illinois three drift sheets are apparently penetrated in well borings. These vary in thickness as noted below.[57]

Upper or Wisconsin drift sheet	50–100 feet.
Middle drift sheet	15–50 "
Lower drift sheet	45–175 "

The upper or Wisconsin till is soft, while the two lower drifts are very hard—hence called by the drillers "hard-pan." Just what the two lower drift sheets are has not been definitely indicated. One is certainly Illinoian. The present aspect of the Iowan drift would seem to exclude that till sheet. It might be the equivalent of the Kansan; or these two lower sheets might be variations of one sheet, the Illinoian. Until more data are available it seems unsafe to claim more than one soil horizon—the Sangamon.

The Sangamon interval is represented in the Upper Illinois Valley, where the river has cut thru the drift deposits. On the west bank of Spring Creek, about a mile below Dalzell,[57a] a section shows the following strata. The life has not been identified as far as known to the writer.

Bloomington till (Wisconsin)	40 feet
Loess	15–20 feet
Silt at base of section crowded with shells and roots of plants (probably Sangamon)	x

c. *Florencia Formation*

Some years ago, Mr. Hershey[58] described a fossil-bearing formation from near Freeport, Stephenson County, to which he gave the name "Florencia Formation," and assigned it to a post-Kansan interval, below the Iowan loess. The formation may be thus briefly described. The basal member (which rests on drift) is composed of coarse, subangular gravel, containing a few mollusks and some drift wood. The thickness is unknown, but is believed to be as much as 20 feet. Resting upon this gravel are three deposits, a dark blue-green silt, light brownish gray sand, and dark brown carbonaceous clay or muck. The thickness of these deposits is variable. The muck is overlaid by laminated and variegated clays. The Florencia deposits are of fluviatile origin and were formed in the bed of an interglacial stream, probably an ancient Pecatonica River.

Hershey says:[59] "It rests upon the Kansan drift sheet everywhere except where post-Kansan erosion has completely removed the till and other glacial deposits. It is, therefore, separated from the latter by an erosion interval of the length of which the interglacial rock gorges of this region are the gauge.

[57] Leverett, *op. cit.*, 142-143.
[57a] Sauer, Bull. Ill. State Geol. Surv., No. 27, p. 73, 1916.
[58] Amer. Journ. Sci., (iv), IV, pp. 90-98.
[59] *Op. cit.*, pp. 93-94.

The Florencia formation passes through these rock gorges, completely burying their flat bottoms. Its age is, therefore, not earlier than the practical completion of these gorges. The Florencia formation is overlain with perfect conformity by the basal member of the Iowan loess series."

The drift sheet called Kansan by Hershey is now correlated with the Illinoian[60] drift-sheet and the Florencia formation thus falls into the Sangamon Interglacial interval. Hershey states that typical upland loess occurs above these deposits. This latter formation possibly includes both Illinoian and Iowan loesses. The Florencia deposits are said to be rather widely distributed in the Pecatonica basin and they are believed by Hershey to be represented in other parts of northwestern Illinois.

The fauna from the Florencia formation is large and varied, including both terrestrial and fluviatile species. It is not specifically stated by Hershey whether some of these came from the old soil (muck). It is a common experience to find land shells in the shore debris mixed with the more common fluviatile shells, tho they by no means occur in such abundance. The list of terrestrial shells seems unusually large, tho there is no reason why these species should not occur in shore debris. They have no connection with the loess. The species listed by Hershey are tabulated below:

Indian Garden Locality	Crane Creek Locality
Pleurocera subulare	*Pleurocera subulare*
Vivipara species, juv.	....
Campeloma decisum	*Campeloma decisum*
Amnicola limosa porata	....
" *cincinnatiensis*	*Amnicola cincinnatiensis*
....	*Somatogyrus depressus*
Bythinella tenuipes	*Bythinella tenuipes*
Valvata tricarinata	*Valvata tricarinata*
Physa heterostropha	*Physa heterostropha*
Ancylus tardus?	....
" *rivularis*	....
" *parallelus*	....
....	*Segmantina armigera*
Planorbis bicarinatus(=*antrosus*)	*Planorbis antrosus*
" *parvus*	" *parvus*
Galba humilis modicella	....
....	*Galba obrussa*
Sphaerium stamineum	*Sphaerium stamineum*
" *striatinum*	" *striatinum*
....	" *simile*(=*sulcatum*)
....	" *solidulum*?
Pisidium walkeri	....
" *cruciatum*	....
" *fallax*	*Pisidium fallax*

[60] Leverett, Illinois Glacial Lobe, p. 167.

Pisidium punctatum	*Pisidium punctatum*
’i *compressum*	" *compressum*
" *variabile*	" *variabile*
....	" *virginicum*
" species	" species
Carychium exiguum	....
" *exile?*	....
Succinea avara	*Succinea avara*
Vallonia perspectiva	....
....	*Vallonia costata*
Strobilops virgo	....
Bifidaria contracta	*Bifidaria contracta*
" *corticaria*	....
" *holzingeri*	*Bifidaria holzingeri*
....	" *armifera*
....	*Vertigo elatior*
....	" *tridentata*
....	*Zonitoides arborea*
Vitrea hammonis	*Vitrea hammonis*
....	" *indentata*
....	*Zonitoides minuscula*
Pyramidula cronkhitei anthonyi	*Pyramidula cronkhitei anthonyi*
....	" *alternata*
Helicodiscus parallellus	*Helicodiscus parallelus*
....	*Polygyra hirsuta*
....	" species
Crustacea	
Cypris	....
Ostracod	....

From near Bolton, Hershey reports *Pisidium abditum?*

d. *Illinoian Loess*[60a]

Loess deposits cover much of the Illinoian drift sheet especially along the banks of the large rivers, such as the Mississippi, Rock, Illinois, Kaskaskia and Wabash. As in Iowa, the loess includes two divisions, an earlier (Illinoian) and a later (Iowan). Possibly some of the loess adjoining the Wisconsin till may be of post-Wisconsin age. In Adams County,[61] in a coal boring near Coatsburg, the relation of the loess to the underlying strata is well shown.

Soil and yellow clay (Iowan loess)..	6	feet
Gray or ashy clay (Illinoian loess)..	4	"
Yellow till, becoming blue near bottom (Illinoian drift)................	10–15	"
Blue-gray till (Illinoian)..	70–75	"
Black soil (Yarmouth)..	2½	"

[60a] See Ante page 251 for the result of recent studies on the great loess deposits of the Mississippi valley.

[61] Leverett, Illinois Glacial Lobe, p. 716.

Stratified clay (Yarmouth)	6	feet
Tough blue clay (Kansan)	20	"

In Pike County a similar division of the loess occurs and Worthen reports the mammoth and *Castoroides* from marl-like deposits, associated with land and fresh water shells.[62] These are probably referable to the post-Illinoian interval.

It is not always an easy matter to discriminate between these two loesses in the matter of fossils when the author has failed to indicate the character of the loess from which they came. Udden[63] lists nine species from Moline, Rock Island County, which are probably referable to the Illinoian loess. These are:

Succinea avara
" *luteola*[64]
" *ovalis(=obliqua)*
Helicina occulta
Pyramidula cronkhitei anthonyi
Sphyradium edentulum alticola
Pupilla muscorum
Bifidaria pentodon
Vallonia pulchella(=gracilicosta?)

From Virginia, Cass County, 13 species are listed.[65]

Helicina orbiculata or *occulta*
Succinea obliqua(=ovalis)
Pyramidula cronkhitei anthonyi(=striatella)
" *alternata*
Oreohelix iowensis (cited as *Helix strigosa*)
Circinaria cancova
Polygyra clausa
" *monodon*
" *multilineata*
" *pennsylvanica*
Galba humilis modicella

Arionta exarata (=*Epiphragmophora*) and *Bulinus dealbatus* are also cited, but these species belong to a totally different part of the United States, and are doubtless examples of erroneous identifications. *Bulimus dealbatus* may be an erroneous name for *Bulinus* or *Aplexa hypnorum*, a species sometimes occurring in the loess.

Loess deposits as well as ancient soils occur in Vermilion County. The old soils are believed to represent the Sangamon interval.[66] A pre-Wisconsin loess also occurs near Danville beneath 15 feet of Wisconsin till.[67] It has been disturbed by the Wisconsin ice and in many places has been incorporated with the upper till. Before the advent of the later ice sheet, the deposit probably included both post-Illinoian and post-Iowan loess, but these have been badly mixed in most exposures and are now indistinguishable. Five small gastropods, typical of the loess, were collected; wood identified as white cedar (*Thuja*

[62] Geol. Pike County, Geol. Ill., IV, p. 36.

[63] Leverett, *op. cit.*, pp. 170-171.

[64] *Succinea luteola* is a distinctly southern species which has never been authentically reported from the loess or from any deposits so far north. It might be *Succinea grosvenori* which is a characteristic loess fossil.

[65] Leverett, Illinois Glacial Lobe, p. 171.

[66] Leverett and Campbell, Danville Folio, pp. 4-5.

[67] Wegemann, Univ. Ill. Studies, III, no. 2.

occidentalis) was obtained from the old soil material. Fossiliferous loess occurs in other parts of the Danville region.

Helicina occulta occurs in Gallatin County with other mollusks.[68] At Freeport, Stephenson County, *Succinea avara* is reported from the loess.[69] Mollusks have also been reported from the loess of White, Hamilton, Henderson, and Mercer counties.

Loess overlies Sangamon soil in Sangamon County, and rests directly upon it, except in a few cases where sand separates the two deposits. It is fossiliferous in many places. The loess in this county doubtless includes both the Sangamon and the Peorian intervals. The fossils are not specifically listed.[70]

Fossiliferous silt or loess covers portions of Boone and Ogle counties. Leverett says:[71] "at the Village of Stratford, five miles east of Polo, the railway exposes a bed of fossiliferous silt at the base of the Iowan drift, resting on an old land surface formed on the Illinoian. . . . In two other localities fossiliferous silts have been found at the base of the Iowan, one being in the railway cuttings on the I.C. immediately west of Irene . . . and another in the railway cutting of the Chicago and Northwestern, . . . one mile east of Belvedere. Here, as at Stratford, the fossils are mainly of the one species (*Succinea avara*)." These deposits should probably be referred to the post-Illinoian loess or Sangamon interval.

The loess (also called a compact silt) extends eastward in a practically continuous sheet from Illinois over southern Indiana, southern Ohio and neighboring portions of Kentucky and West Virginia and is the superficial deposit as far north as the border of the Wisconsin drift sheet. It is known to underlie the Wisconsin drift, numerous exposures having been found beneath that drift.[72] It is called white clay in the early Ohio reports and slush land in the Indiana reports. As in Illinois, this loess probably includes both the Sangamon and the Peorian intervals altho all have been referred to the Iowan age by Mr. Leverett.

e. *Vertebrates*

Mammals have been reported from various deposits of Sangamon age. In Madison County,[73] above the City of Alton, the remains of a mastodon were found 30 feet below the surface, near the bottom of the loess, where it was separated from limestone by 2-3 feet of local drift (Illinoian). The loess above contained land and fresh water shells. A mastodon was also found in Peoria

[68] Geol. Ill., VI, p. 213.

[69] Hershey, Amer. Journ. Sci., (iv), IV, p. 98.

[70] Shaw and Savage, Tallula-Springfield Folio, p. 8.

[71] Leverett, Illinois Glacial Lobe, p. 138.

[72] Leverett, Mon. XLI, p. 295.

[73] Worthen, Geol. Ill., I, p. 315.

County which appears to be referable to the Sangamon. A well section near the City of Peoria presented the following order of strata:[74]

1	Brown prairie clay and soil	12 feet
2.	Coarse gravel and sand with boulders (Wisconsin)	35 "
3.	Clay and sand, forming 7–8 distinct beds, some containing coarse gravel and boulders (Illinoian)	48 "
4.	Black, mucky soil, with limbs of trees, etc. (Yarmouth)	2 "
5.	Boulder clay (Kansan)	8 "
	Height of section	105 "

In the bluff near Peoria a mastodon was found in a gravel bed, believed to be the equivalent of number 2 in the above section. In Washington County (at Beaucoup)[75] a mastodon is reported from reddish clay below yellow clay, at a depth of about 18 feet below the surface, and in Marion County (at Sandoval) a mastodon was observed in the same stratum at 12 feet below the surface. In Ogle County[76] a mastodon tooth was secured from a tributary of Stillman's Run and leg bones were found in the bank of Rock River at a depth of 5 feet, 15 feet above the river.

The elephant jaw recorded by McAdams[77] from Calhoun County may be referable to the Sangamon. It was from drift clay, in the side of a ravine. A mammoth tooth from Christian County, found in a sand drift near the South Fork of the Sangamon River, may be referred to the same horizon. In Gallatin County the remains of the mastodon and the mammoth have been found in Sangamon deposits. At 'Half Moon' both the mammoth and mastodon occur in a yellowish clay mixed with gravel, which underlies a salt lick. In Shawneetown mastodon teeth were found embedded in a shallow deposit of bluish clay resting on yellow clay and gravel.[78] The *Castoroides* reported by LeConte from a well near Shawneetown, 40 feet below the surface, may also be referable to the Sangamon interval.[79] Two records from Henry County are thot to belong to the Sangamon. Near Cambridge a part of a tusk was found in a well 16 feet below the surface and from Penny's Slough a tooth was secured. This latter may belong to a later time, however, perhaps post-Wisconsin.

A number of records of mammals have been reported from Rock Island County.[80] At Milan a tusk was found in the red 'ferretto' zone; at Rock Island, in a cut thru the loess, which is here 35 feet thick, a tooth and a piece of a leg bone of an elephant were found at a depth of 22 feet. The lower part

[74] *Op. cit.*, V, p. 236.
[75] Foster, Proc. Amer. A. A. Sci., X, p. 161.
[76] Shaw, Geol. Ill., V, p. 110.
[77] Trans. St. Louis Acad. Sci., X, No. 3, p. LXXIX.
[78] Anderson, Augustana Library Pub., No. 5, pp. 10-11.
[79] Proc. Phil. Acad., VI, p. 53.
[80] Anderson, *op. cit.*, p. 17.

of the loess is slightly peaty, probably representing the Sangamon soil. A carpal bone was found in the same clay. A tooth found in Rural Township may have been derived from the Sangamon deposits.

The bones of several mammals, as well as the remains of other animals, were reported by Worthen[81] from a point between Niantic, Macon County, and Illiopolis, Sangamon County. Worthen says: "the Niantic mastodon was found on the farm of W. F. Corell, in a wet, spongy piece of ground located in a swale or depression of the surface that had evidently once been a pond and had been filled up by the wash from the surrounding highland until it formed a morass or quagmire in dry weather. The bones were about four feet below the surface and partly embedded in light gray quicksand filled with fresh water shells. Above this quicksand was found four feet of black peaty soil, so soft that a fence rail could easily be pushed down through it. The quicksand had evidently once formed the bottom of a fresh water pond, fed probably by springs, and was the resort of the animals whose bones were found here." The species of animals found in this deposit are listed below:

Mastodon (*Mammut americanum*)
Elk (*Cervus canadensis*)
Buffalo (*Bison bison?*)
Deer (*Odocoileus virginianus*)
Physa (*Physa* species)
Planorbis (*Planorbis* species)
Cyclas (*Sphaerium* species)

This deposit is outside of the Wisconsin drift and rests on Illinoian drift, hence it appears referable to the Sangamon interval.

A tooth of *Elephas primigenius* was found in an excavation at the Kewanee works of the National Tube Co., at Kewanee, Henry County. It was found at a depth of 12 feet in undisturbed yellow clay, and is probably referable to the Sangamon interval (specimen in Museum of Natural History, University of Illinois).

In Adams County, especially near Quincy, the loess is 30-40 feet thick and is underlaid by a foot or more of chocolate-colored clay containing twigs and other vegetable remains (the Sangamon soil). At Alton, Madison County, and Chester, Randolph County, a number of mammals occur in deposits referable to the Sangamon. These are identified by Worthen as follows:[82]

Mastodon	*Bos primigenius*
Mammoth	*Castoroides ohioensis*
Megalonyx	Several small rodents

Mollusks are said to have been found with the mammals.

[81] Geol. Ill., V, p. 308; VIII, p. 23; Amer. Nat., V, p. 607.
[82] Geol. Ill., IV, p. 46; VIII, p. 8.

The mastodon mentioned by Udden[83] as being found in a gravel pit (Adam Saal's) between Dead Lake and the river channel, a mile south of Pekin, in sand, under gravel, is probably referable to the Sangamon interval. The overlying gravel is said to be of Wisconsin age.

The horse appears to have lived during the Sangamon interval as its remains occur in strata referable to this horizon.[84] The maxillary bone with a few teeth were found in a bog on the confines of Bond and Fayette counties.[85] The species was identified as *Equus complicatus*. Both the horse and the bison (*Bison latifrons*) have been reported[86] from Illinois, the former from Greene County and Alton, Madison County, and the latter from near Alton. The horizon from which these specimens came is, however, indefinite. *Bison latifrons* [7] has also been reported from the Kaskaskia River, Moultrie County, in dark clay and debris. Details are not given but the deposit is possibly Sangamon, beneath Wisconsin till. Illinoian drift has been identified beneath 160 feet of Wisconsin till at Barrington, Lake County but no biotic material has been recorded.[88]

3. INDIANA

a. *Old Soils*

In Indiana deposits referable to the Sangamon interval have been recorded from several localities. In Delaware County[89] well diggers encounter a layer of vegetable material at a depth of about 40 feet, composed of stumps and trunks of trees, twigs, leaves, and vegetable mold. In Boone County[90] black muck or loam, with branches of trees and other vegetable matter is reported beneath the Wisconsin drift. In Ripley and Decatur counties[91] old soils have been reported which should probably be referred to the Sangamon. At Seymour,[92] Jackson County, an old flood plain of the White River is also probably referable to this stage. The great majority of the buried soils reported in Indiana, Illinois, and Ohio appear to belong to the Sangamon interval.[93]

At the edge of the Illinoian drift in Dearborn, Ohio, and Switzerland counties several interesting sections have been exposed.[94] Well sections in

[83] Bull. 506, U. S. G. S., p. 61.

[84] Hay, Science, N. S., XXX, p. 891.

[85] Leidy, Trans. Wagner Free Inst. Sci., II, p. 39; Gidley, Bull. Amer. Mus. N. H., XIV, p. 91.

[86] McAdams, Trans. St. Louis Acad. Sci., X, p. LXXX.

[87] Broadhead, Amer. Nat., IV, pp. 61-62.

[88] Leverett, Ill. Glacial Lobe, p. 581.

[89] Phinney, Geol. Ind., 11th An. Rep., p. 130.

[90] Gorby, *op. cit.*, 15th An. Rep., pp. 167-173.

[91] Blatchley, *op. cit.*, 29th An. Rep., pp. 431, 432.

[92] Leverett, Mon. XLI, p. 263.

[93] Leverett, *op. cit.*, p. 293.

[94] Warder, Geol. Surv. Ind., 3-4 An. Rep., p. 404.

Ohio and Switzerland counties show the following strata: (I, NW ¼ Sect. 6, T. 3, R. 2 W.; II, Sect. 4, T. 5 R. 12 E.)

I

Soil and clay	22	feet
Yellow sand, quite hard or cemented	9	"
Blue clay, quite hard, without pebbles	1½	"
Rotten leaves, twigs, black soil, wood, and thick bark	1½	"
Coarse sand, gravel and shelly stone	9	"
Hard blue limestone	1	"
Height of section	44	feet

II

Soil and clay, more whitish at lower part	22	feet
Blue mud, resembling recent alluvium	6	"
Black soil containing leaves, cedar wood and ochreous particles	3	"
Small stones packed together like a macadamized road	1	"
Height of section	32	feet

The old soil and wood are evidently referable to the Sangamon interval.

At Lawrenceburg, Dearborn County, organic remains occur which are to be referred to the Sangamon interval. A section of the river bank presents the strata as shown below:[95]

1. Soil	1–2	feet
2. Clay	6	"
3. Sand, clay, gravel, loam	30	"
4. Ochreous sand (containing land shells)	1½	"
5. Carbonaceous clay containing old forest bed and ancient soil	7	"
6. Ochreous sand	1½	"
7. Clean gravel	6	"
Low water	x	
Height of section	53	feet

The forest bed contains six species of plants.

Platanus occidentalis	*Aesculus glabra*
Fagus ferruginea	*Juniperus viginianus*
Carya alba	*Echinocystis lobata?* (seed only)

A rich fauna of land mollusks occurs above the forest bed in the ochreous deposit; 29 species being listed by Billups.[96] The shells were first seen in

[95] Orton, Geol. Ohio, I, p. 428.

[96] Nautilus, XVI, p. 51.

drift along the river shore of the Ohio and the Miami. Later these were traced to their source in the geological deposit.

Vallonia pulchella. Traces only.
Polygyra tridentata. More elevated and more deeply striated than recent form.
" *tridentata*, var. Mouth much depressed; deeply striated.
" *inflecta*
" *profunda*
" *albolabris.* Scarce
" *exoleta* (=*zaleta*)
" *multilineata.* Not found alive within 20 miles of Lawrenceburg.
" *palliata*
" *appressa*
" *elevata*
" *pennsylvanica.* Rare alive in vicinity.
" *thyroides*
" *mitchelliana.* Rare alive.
" *stenotrema*
" *monodon.* Very rare.
Pupoides marginatus
Bifidaria contracta
" *armifera*
Cochlicopa lubrica
Circinaria concava
Vitrea hammonis
Gastrodonta ligera
Pyramidula alternata
" *solitaria*
" *cronkhitei anthonyi*(=*striatella*). Rare.
" *perspectiva.* Rare.
Helicodiscus parallelus. Rare.
Succinea species. Nothing as large found in the vicinity.
Pomatiopsis lapidaria. Never found alive near Lawrenceburg.

Forest beds are also found at Hickman's Landing, Switzerland County, two miles above Florence. This bed of blue clay, which contains leaves and wood and is 4½ feet thick, may be traced in the river bank without interruption for 20 rods. Ochreous deposits occur above and below this deposit, as at Lawrenceburg.[97] Leverett[98] believes that the old soil at Lawrenceburg is of Sangamon age and overlies Illinoian drift, the upper deposits, often aggregating 85 feet in thickness, being referable to Wisconsin age.

In Gibson County Sangamon soil is frequently noted beneath loess deposits and above Illinoian till. A section, situated four miles west of Wadesville,[99] indicates the position of this soil.

[97] Warder, Geol. Surv. Ind., 3-4 An. Rep., p. 408.
[98] Mon. XLI, p. 267.
[99] Fuller and Clapp, Patoka Folio, p. 4.

Marly soil	3 feet
Clay (marl loess)	30 "
Rich soil, logs, etc. (Sangamon)	3 "
Blue mud and gravel	10 "
Quicksand (stratified drift)	1+"

Several exposures in northern Indiana indicate the presence of old soils and peat beds beneath the Wisconsin till. In Boone County, near Jamestown, a well section gave the strata noted below:[100]

1. Soil and yellow clay mixed with sand	12 feet
2. Yellow sand	2 "
3. Hard gravel	4 "
4. Hardpan and gravel	4 "
5. White sand	6 "
6. Sand and clay, bluish	18 "
7. Black muck or loam, with branches of trees and other vegetable matter	12 "
8. Blue clay	4 "
9. Gray sand, gravel, etc	26 "

The stratum number 7 is probably of Sangamon age.

An excavation in Main Street, Lebanon, exposed mollusks beneath clay, as noted below:[101]

Soil	2 feet
Clay	12 "
Sand with large number of shells said to be fresh water	x "
Gravel	x "

If the 14 feet is Wisconsin drift, the thinness is very unusual. It may possibly be postglacial. Several other records of pre-Wisconsin soil in Boone County are known, indicating the deposits to be widespread.

Ancient stream channels near Richmond: "The cut through this formation for the passage of the national road, exposes the beds of no less than three small streams, which appear to have run parallel with the present one, and are now covered by a thick deposit of diluvium. The section of the largest one, which is on the west side of the river (Whitewater), presents the following appearance on the north side of the road.

"The bed of this ancient stream is about 400 feet from the escarpment of the present river, whose waters flow nearly 12 fathoms below, in perpendicular measurement. The silt is 6 feet deep, and consists of a dark bluish earth, strongly contrasting with the yellowish diluvial clay above it. This silt contains no bowlders, but pockets of coarse sand and pebbles of various sizes are found in it. The diluvium which fills up the remainder of the channel is about 10 feet thick immediately over the silt, and is the same that forms the

[100] Gorby and Lee, Geol. Surv. Ind., 15th An. Rep., p. 167.
[101] *Op. cit.*, p. 167.

general surface of the country; bowlders, however, are much more numerous in the course of the obliterated stream than in any other part of the diluvium exposed to view by the cut for the road.

"In the silt, removed for the passage of the national road, sticks and other vegetable matter were found; and in portions of this fluviatile deposit which I have examined, I have detected at various times, small soggy pieces of wood, such as we find at the bottom of existing waters; also fragments of the ribs of leaves and their nervous ramifications, and a well characterized piece of pine."[102] No shells were found.

Wood has been found at Springboro, 44 miles west of Richmond, Wayne County, at a depth of 14 feet. Wood with marks of the teeth of the giant beaver (*Castoroides*) was also found near Richmond. Some of the wood was thot to be pine; other fragments resembled *Platanus occidentalis*. Wood was also found in Madison County, at a depth of 27 feet; it was thot to be elm.

Leverett[102a] records interglacial deposits in Putnam and Owen counties, but remarks that he is hardly prepared to express an opinion as to the age of the buried soils in southern Indiana. The Sangamon appears to be represented in Putnam County, a ravine exhibiting the following section (*op. cit.*, p. 63):

Surface silt or clay, white, pebbleless; apparently a correlation of the main loess deposit of the Mississippi basin	4–6 feet
Soil, black, gummy, or gumbo, with quartz pebbles, representing apparently the Sangamon Interglacial soil	1–3 "
Till, brown, generally with deeply weathered surface, apparently of Illinoian age	3–15 "
Gumbo, black, changing to blue or gray below; generally containing a few pebbles	1–8 "
Till, brown, extending to bottom of ravine, in places changing to blue; exposed	5–10 "

"Twenty feet or more of the black mucky material is reported beneath the upper sheet of till in certain wells in the region, but no exposure exceeding 8 feet was found in ravines."

"In La Grange County, a well about four miles south of La Grange, on the farm of Dr. Drake, is reported to have penetrated a buried soil. The records of the borings are as follows" (*op. cit.*, p. 145):

Record of Prospect Boring at La Grange Jail

Till, yellow	15 feet
Till, blue, with thin beds of sand	50 "
Mould or soil, brown (Sangamon?)	4 "
Gravel, cemented	5 "
Gravel, loose, with water	8 "
Till, blue (Illinoian?)	45 "
Gravel, cemented	8 "
Sand and gravel, dry, or sandy till	70 "
Total depth	205 feet

[102] Plummer, Amer. Journ. Sci., (i), XLIV, pp. 286-287.

[102a] Mon. LIII, U. S. Geol. Surv., pp. 64-71, and elsewhere.

Record of Drake Well near La Grange

Till, sandy, yellow	10 feet
Till, blue	41 "
Gravel, with inflammable gas	3 "
Clay, blue (till?)	46 "
Muck, black, with leaves and gas	6 "
Clay, soft, blue; no pebbles noted	24 "
Sand, water-bearing, coarse near bottom	10 "
Total depth	140 feet

Of the buried soils of Indiana, Leverett says, (p. 64) "The buried muck beds are perhaps as conspicuous in these flat areas among the hills of central Indiana as are those found between the Illinoian and Kansan drift sheets of southeastern Iowa, but they are not underlain by the highly weathered and oxidized till sheet that characterizes the upper part of the Kansan drift in Iowa. The results of the study, therefore, leave the occurrence of a long interval of deglaciation in doubt."

b. *Loess*

Loess deposits extend up the Wabash and Ohio valleys for many miles and cover, also, much of the intervening territory in southwestern Indiana. Near the rivers a type of loess known as marl-loess occurs which is usually very fossiliferous. The thickness above the Illinoian till or indigenous rock varies from 10 to 30 or 40 feet. This deposit is said to be of aqueous origin,[103] but the fossil species represented do not bear out such an origin. There is no apparent reason for ascribing the deposits in which the land shells were found to agencies other than aeolian.

Organic remains are reported as follows:[104]

Pike County, 1½ miles northwest of Petersburg.

Zonitoides arborea
Polygyra monodon
" *multilineata*
Succinea lineata (=*grosvenori*)
Galba humilis modicella
(reported as *Succinea humilis*)

Gibson County, Hazelton, opposite the railroad station.

Zonitoides arborea
Bifidaria armifera
Pyramidula alternata
Polygyra hirsuta
Polygyra albolabris
Succinea lineata (=*grosvenori*)
Helicina occulta

Shells were also found at Patoka, Posey County, 1½ miles east of New Harmony.

Euconulus fulvus
Bifidaria armifera
Vertigo tridentata
Vallonia cyclophorella
Succinea lineata (=*grosvenori*)
Pomatiopsis lapidaria

[103] Fuller and Clapp, Bull. Geol. Soc. Amer., XIV, pp. 166-168, et seq; see also Shaw Science, N. S., XLI, pp. 104-108, 1915.

[104] *Op. cit.*, pp. 161-162.

Posey County, ¾ mile south of New Harmony.

Zonitoides arborea	*Polygyra monodon*
Euconulus fulvus	*Succinea lineata* (=*grosvenori*)
Strobilops labyrinthica	*Helicina occulta*
Polygyra hirsuta	*Pomatiopsis lapidaria*

One mile southeast of Kilroy.

Polygyra elevata	*Circinaria concava*
" *thyroides*	*Succinea lineata* (=*grosvenori*)

Three-fourths mile southwest of Stewartsville.

Zonitoides arborea	*Polygyra hirsuta*
Euconulus fulvus	" *thyroides*
Strobilops labyrinthica	*Succinea lineata* (=*grosvenori*)
Helicodiscus lineatus(=*parallelus*)	*Galba humilis modicella*

Other localities in Posey County are, 2 miles north of Grafton and 1 mile southwest of Poseyville. One mile west of Mounts, Gibson County, a deposit occurs which must have been formed in water as the shells are all aquatic. This was probably a pond or stream which later was partly drained and finally filled with loess. Six species have been identified, as noted below:

Galba humilis modicella	*Valvata tricarinata*
Planorbis parvus	*Pisidium variabile*
" *bicarinatus* (=*antrosus*)	" *compressum*

Near Mt. Carmel and Keensburg, in Wabash County, Illinois, loess fossils were also found. From two of the best known Indiana localities, New Harmony and Grand Chain, Daniels collected 26 species. The loess is here covered with two feet of soil; the shells occur from 6 to 15 feet below the surface, being more plentiful from the middle to the bottom of the deposit. *Polygyra monodon* is abundant in the loess, but no living specimens occur here or elsewhere in the state except on the marshes bordering several of the lakes in the northern part of the state, where it is abundant.[105] The species noted by Daniels are listed below.[106]

x *Helicina occulta*	*Vitrea hammonis*
Vallonia pulchella	" *wheatleyi*
Polygyra multilineata	*Euconulus fulvus*
x " *hirsuta*	*Zonitoides nitida*
x " *monodon*	" *arborea*
x " *fraterna*	*Gastrodonta ligera*
Strobilops labyrinthica	*Pyramidula alternata*
" *affinis*	" *perspectiva*
Pupoides marginatus	" *cronkhitei anthonyi*
Bifidaria armifera	*Helicodiscus parellelus*

[105] Daniels, Nautilus, XIX, p. 62.

[106] *Op. cit.*, p. 63; x indicates abundant.

Bifidaria contracta	*Succinea retusa*
Circinaria concava	" *avara*
Omphalina inornata	x *Pomatiopsis lapidaria*

It will be noted that the list of Fuller and Clapp includes a number of species of land shells not recorded by Daniels. These are:

Succinea lineata (=*grosvenori*)	*Vertigo tridentata*
Polygyra albolabris	*Vallonia cyclophorella*
" *elevata*	*Galba humilis modicella*
" *thyroides*	

Succinea lineata is considered a synonym of *S. grosvenori* (vide Pilsbry, Proc. Phil. Acad., 1906, page 161). *Grosvenori* is not given in Daniels list, nor is it quoted in any list of Illinois or Indiana fossils. It is a common loess fossil in Iowa and there is no reason why it should not occur in the same deposits in Illinois and Indiana. Its occurrence is paralleled by the presence of *Oreohelix iowensis*, *Pyramidula shimekii* and *Sphyradium edentulum alticola*, species which are now found living westward in a drier climate.

The list published by Cox, which follows, also contains species not listed by either of the previously mentioned authors. It is possible that in the older list there may be some errors of identification. Cox lists 18 species from New Harmony, 5 of which do not occur in Daniels lits.[107] These are marked with an x.

Circinaria concava	*Polygyra hirsuta*
Zonitoides arborea	" *monodon*
x *Vitrea indentata*	" *fraterna*
Pyramidula perspectiva	*Vallonia pulchella*
Helicodiscus parallelus(=*lineatus*)	*Succinea avara*
Bifidaria armifera	x " *elongata*
x *Leucochila fallax*	*Pomatiopsis lapidaria*
Strobilops labyrinthica	*Helicina occulta*
x *Punctum pygmaeum*	x *Valvata tricarinata*

The last species is doubtful, as it is not found in true loess. The *Succinea elongata* in the above list, as well as in the following list, is probably Say's *Physa elongata*(=*Aplexa hypnorum*) as there is no *Succinea elongata* in America.

In Sullivan County, along the Wabash River and Busseron Creek, a fossiliferous loess occurs overlying Illinoian drift. The following species have been identified.[108]

Circinaria concava	*Helicina occulta*
Polygyra fraterna	*Succinea elongata?*
" *monodon*	" species
" *hirsuta*	*Bifidaria armifera*
Strobilops labyrinthica	*Pomatiopsis lapidaria*
Pyramidula perspectiva	*Helix minuta* (=*Vallonia pulchella*)

[107] Geol. Surv. Ind., 8, 9, 10 An. Rep., pp. 119-120; 6th An. Rep., p. 7.

[108] Collett, *op. cit.*, 2nd Rep., pp. 226-227.

These deposits include two loesses, an upper light yellow loess, and a lower, darker loess. The first is post-Iowan (Peorian) while the second is post-Illinoian (Sangamon). Shimek[109] refers the lower loess to the post-Kansan interval, but as it lies on the Illinoian drift it is later than the post-Kansan interval (Yarmouth), and must be considered as of Sangamon age. The lower loess is exceedingly fossiliferous, the upper much less so, in fact, containing but few examples. On the Kentucky side of the River, near Henderson, the marl-loess contains several species of helices, *Bifidaria armifera*, *Succinea*, and *Pomatiopsis* (*Cyclostoma*).[110]

Deposits of mussel shells have been exposed in the bank of the Ohio River near Florence, Switzerland County. These are from 3 to 10 feet below the surface. The shell beds are said to have been deposited by Man, but this statement it would seem, is open to grave question. They are probably natural deposits, belonging to the Sangamon or to a later period.[111] In the river bank opposite Florence the shell bed is 32 inches beneath the surface. Other deposits also occur.[112]

c. *Mammalian Fauna*

Mammals referable to Sangamon age are present in Indiana deposits. Mastodon remains were exhumed some years ago at Wm. Cordery's sand bank, 300 feet west of the Madison and Indianapolis Railroad, 12 feet below the surface, in a sand and gravel deposit.[113] In Martin County both the mastodon and the mammoth are reported from marsh clay, resting on drift.[114] In Dearborn, Ohio, and Switzerland counties, in various deposits overlying Illinoian drift, the remains of the mammoth and the mastodon have been observed. Many of these deposits are in the river bank. Mastodon remains have been recorded from various deposits, many of which are probably referable to the Sangamon interval. These are listed below:

Clarke County; near Charleston Landing, Ohio River, above Louisville, Ky., in sand bank.[115]

Dearborn County; five miles west southwest from Aurora, on blue clay, 8-9 feet below the surface.[116]

DuBois County; near mouth of Wolf Creek, at "Rock House," ford of the White River.[117] East branch of White River.[118]

[109] Journ. Geol., XIII, No. 3, p. 232.
[110] Leidy, Smith. Contr. Knowl., VII, Art. V, pp. 7-8.
[111] Geol. Surv. Ind., 3rd and 4th An. Rep., pp. 408-409.
[112] *Op. cit.*, p. 414.
[113] Borden, Geol. Surv. Ind., 6th An. Rep., p. 141.
[114] Cox, *op. cit.*, 2nd An. Rep., p. 103.
[115] Borden, Geol. Surv. Ind., 5th An. Rep., p. 176; Hay, 36th An. Rep., p. 700.
[116] Hay, *op. cit.*, p. 701.
[117] Collett, *op. cit.*, 4th An. Rep., p. 214.
[118] Hay, 36th An. Rep., p. 703.

Gibson County; Princeton, in excavation for sewer in west Chestnut Street, at depth of 6 feet.[119]

Jackson County; in bank of Judah Creek, a branch of Mill Creek.[120]

Martin County; near Shoals, brot up on a fishing line.[121]

Switzerland County; in gravel bank at mouth of Grant's Creek; river bank near Patriot; river bottom, five miles below Vevay; Laughery Creek, above Hartford; Rising Sun, on river bank. The exact age of these remains, consisting of teeth and tusks, is in question.[122] Some of them are probably of Sangamon age.

Franklin County; near Brookville, at three localities; a mile below Brookville; three and a half miles from the town, in gravel in the upper terrace, 8-9 feet below the surface; three and a half miles northwest of Brookville, in a piece of marshy ground which had been ditched.[123] The last reference may belong to post-Wisconsin time, but the first two were found in gravel which antedates the Wisconsin stage.[124]

Elephas columbi and *E. primigenius* are both known to have lived in Indiana but the horizon of most of the "finds" is doubtful. The following may have been from Sangamon strata:

Elephas primigenius. One and a half miles below Vevay, Switzerland County, on shore of Ohio River.[125]

Elephas columbi. Fifteen miles west of Brookville, Franklin County, in a gravelly bank of Salt Creek (Butt's Fork).[126] In Vigo County, near Terre Haute, on a farm, a lower molar tooth was found at a depth of 18 feet.[127] As Terre Haute lies near the edge of the Wisconsin drift sheet, which is here underlaid by Illinoian drift, the inference is that at this depth (18 feet) the deposit would cover the Illinoian drift, and the tooth would be of Sangamon age.

The remains of elephants, the species of which are not indicated, have been found in strata possibly referable to the Sangamon interval. Many years ago Plummer reported a tusk from near Brookville, dug from the Whitewater canal at a depth of 15 feet, the deposit being gravel.[128] The mammoth has been reported from Martin County[129] (near Shoals) but these remains cannot be referred to any definite horizon.

[119] Hay, *op. cit.*, p. 705.

[120] Cox, *op. cit.*, 6th An. Rep., p. 59.

[121] Hay, *op. cit.*, 36th An. Rep., p. 709.

[122] Hay, *op. cit.*, p. 714.

[123] Haymond, Geol. Surv. Ind., 1st An. Rep., 1869.

[124] Hay, *op. cit.*, 36th An. Rep., p. 704.

[125] Hay, *op. cit.*, p. 733.

[126] Haymond, Amer. Journ. Sci., (i), XLVI, pp. 294-296; Hay, *op. cit.*, p. 742. First citied as tooth of *Megatherium*.

[127] Hay, *op. cit.*, p. 746.

[128] Amer. Journ. Sci., (i), XLIV, p. 302.

[129] Cox, Geol. Surv. Ind., 2nd An. Rep., p. 103; Hay, *op. cit.*, 36th Rep., p. 748.

The tapir (*Tapirus haysii*) is recorded by Cope[130] from near Richmond, Wayne County, but the record has not been subsequently substantiated.[131] *Bison antiquus*[132] has been recorded from near Vincennes, Knox County. A skull was found in a ditch at a depth of 6 feet. This is believed by Hay to belong to pre-Wisconsin time and it may be referred to the Sangamon interval with a considerable degree of certainty.

In Bartholomew County mammal remains are reported as follows, possibly from Sangamon deposits.[133]

Species	Locality
Mammut americanum.	Sand bar in White River, one mile east of Walesboro.
Elephas primigenius.	In gravel pit one-half mile south of Walesboro, under 7 feet of soil and gravel.
Alces americanus.	In White River, one mile east of Walesboro.
Odocoileus virginianus.	Wayne Township.

In a limestone cave in Rock Cliff Quarry, just northwest of Williams, in Lawrence County, the remains of several animals were found in a stalagmitic deposit 20-30 feet below the level of the ground. Hay[133a] remarks that the age of the deposit cannot be determined but that the animals probably lived before the oncoming of the Wisconsin ice. It seems quite proper to refer this material to the Sangamon interval. Three species are represented, as noted below:

Terrapane carolina. Shell.
Tayassu lenis. Jaws and teeth.
Platygonus vetus. Molar.

4. OHIO

a. *Old Soils*

The Sangamon interval has been identified from Ohio by Leverett and the records of some of the old soils and forest beds published by Ohio geologists should doubtless be referred to the same horizon. In Fairfield County[134] this soil occurs at Clearport, between the surface soil and Illinoian drift, and at Lancaster, between the Wisconsin and Illinoian tills. From German Township, Montgomery County, Dachnowski[135] reports a Sangamon peat bed beneath 80-100 feet of stratified clay and gravel (Wisconsin). This bed is exposed in the channel of Twin Creek, a tributary of the Miami River. The peat is from 1 to 4 feet in depth and the upper layers contain sphagnum mosses.

[130] Journ. Phil. Acad., XI, p. 253.
[131] Hay, Geol. Surv. Ind., 36th Rep., p. 591.
[132] Middleton and Moore, Proc. Ind. Acad. Sci., 1899, pp. 178-181; Hay, *op. cit.*, p. 651.
[133] Edwards, Proc. Ind. Acad. Sci., 1901, pp. 247-248, 1902.
[133a] Iowa Geol. Surv., XXIII, pp. 553, 596, 605.
[134] Leverett, Mon. XLI, p. 269.
[135] Bull. 16, Geol. Surv. Ohio, p. 103.

The lower layers contain woody fibers. The peat rests on a bed of fine sand several feet in thickness, which in turn is underlaid by clay and gravel. The sand often contains trunks, roots, and branches of trees and also berries of cedar (*Juniperus virginianus*). The wood is partly coniferous, but ash, hickory, sycamore, beech, and wild grape also occur. The tusks of the mastodon were also found. The peat bed is said to be of wide extent. In Columbus County, near Matville,[136] a section shows the Sangamon soil underlaid by Illinoian drift. The section is in the east bluff of Big Darby Creek and the succession of strata is as noted below:

4. Weathered till and present dark soil grading into the next (Wisconsin)	3–4 feet
3. Fresh, loose, stony yellow clay till, with sharp contact between it and no. 2 (Wisconsin)	12–5 "
2. Much weathered, dark, compact soil-like material gradually passing into the next below (Sangamon)	2–4 "
1. Characteristic dense, blue old drift (Illinoian)	50 feet

A similar section is published by Hubbard [137] from Springwater Run, near Harrisburg, the old soil being overlaid by 30 feet of Wisconsin till. In Hocking County Sangamon soils with forest remains are frequently encountered. Near Palmyra and Springfield old soils with limbs of trees, sticks, leaves, etc. are recorded at depths of 16, 18, 20, 24, 26, 30 40, and 45 feet beneath the surface. Every well dug encounters this deposit.[138]

An earlier till sheet with overlying interglacial deposits has been recognized in northern Ohio. Carney[139] distinguished an earlier, bluish clay under a yellow clay near Cleveland, and Scudder[140] has identified four species of beetles from clay beds believed to be interglacial, which occur near Cleveland. The deposits are similar to those at Scarboro, Canada. The four species are:

Hydrochus amictus — *Pterostichus dormitans*
Helophorus rigescens — *Bembidium fragmentum*

Wright[141] has described a deposit at Amboy, Ashtabula County, which may be referable to the same horizon from which the insects mentioned above were obtained. Many logs were noted, lying side by side, covered by 30 feet of gravel, in which was found a tooth and a tusk of the mammoth. The log deposit is 140 feet above Lake Erie.

[136] Bull. 14, Geol. Surv. Ohio, p. 67.
[137] Bull. 14, p. 66.
[138] Silliman, Amer. Journ. Sci., (i), XXV, pp. 104-107.
[139] Journ. Geol., XVII, pp. 473-487.
[140] Contr. Can. Pal., II, part 1, page 27; Amer. Journ. Sci., (iii), XLVIII, p. 182.
[141] Proc. Amer. As. Ad. Sci., XLVII, p. 298.

b. *Fluviatile Deposits*

An interesting deposit occurs at Cincinnati, Hamilton County, which contains a small fauna. A section, made 20 years ago, is indicated below:[142]

Yellow clay	5 feet 8 inches
Blue clay	7 " 3 "
Height of section	13 feet 1 inch

The contact portions between the two clays contained fragments of wood and vegetation in one place, which probably represented the Sangamon soil horizon. The blue clay contained sand pockets containing the following species of shells:

Physa ancillaria	*Planorbis parvus*
Anculosa costata (of small size)	

Equus fraternus and *Mammut americanum* were also secured from the blue clay. The yellow clay is probably loess.

Many years ago, Hildreth[143] described a well boring which passed thru strata evidently referable to the Sangamon interval; the lower strata may, however, be of older date. As the region is far outside of the till margin, the age of the deposits cannot be placed with certainty. Valley drift from the Illinoian and Wisconsin drift sheets extends down the Muskingham River to the Ohio. The well was located six miles above the mouth of the Muskingham River and one and one-half miles north of the Ohio River. The section included the following strata (correlation the writers):

1. Ash colored clay (probably loess)	40 feet
2. Blue clay with fragments of plants, leaves, and seeds of monocotyledenous plants; beneath this a bed of wood, leaves and plant remains (Sangamon old soil?)	10 "
3. Fine siliceous and micaceous sand, the upper part mixed with blue clay such as is now found in the bottom of fresh water ponds or in eddies and lagoons of large rivers. Scattered throughout the 10 feet, and especially in the upper portion, are numerous fluviatile shells apparently Unio and Anodonta. (Sangamon or possibly Yarmouth)	10 "
Depth of well	60 feet

The Unios are given names by Morton and are also figured, but the cuts are not good enough for identification with recent species. These names, which are not recorded in Simpson's Synopsis, are listed below:

Unio	*petrosus*	Morton.	Plate 1	figure 17.	Page 149
"	*tumulatus*	"	" 1	" 18–21.	" 149

[142] Hayes, Journ. Cin. Soc. Nat. Hist., XVII, pp. 217-226.
[143] Amer. Journ. Sci., (i), XXIX, pp. 17, 149, plate 1, 1836.

Unio terrenus	Morton.	Plate 1	figure 19.	Page 149
" *saxulum*	"	" 1	" 20.	" 149
Anodonta? abyssina	"	" 1	" 22–23.	" 149

With the Unios "one perfect form of a genuine oyster and several fragments" were found. What these really were it is impossible to conjecture. The molluscan record is practically worthless for the present purpose.

Near Middletown, Butler County, in the first bottoms of the Miami River, a stratum containing mollusks occurs which is evidently referable to the Sangamon interval. It is to be correlated with the old shell and forest beds near Lawrenceburg, Indiana, and in other parts of the Ohio Valley. Thirteen species are recorded from Middleton.[144]

Name listed.	Present name.
Helix elevata	*Polygyra elevata*
" *concava*	*Circinaria concava*
" *alternata*	*Pyramidula alternata*
" *hirsuta*	*Polygyra hirsuta*
" *monodon*	" *monodon*
" *thyroideus*	" *thyroides*
" *profunda*	" *profunda*
" *solitaria*	*Pyramidula solitaria*
" *tridentata*	*Polygyra tridentata*
Goniobasis depygis	*Goniobasis depygis*
Planorbis trivolvis	*Planorbis trivolvis*
Amnicola lapidaria	*Pomatiopsis lapidaria*
Succinea species	*Succinea* species

c. *Mammalian Fauna*

Mammals of Sangamon age occur above the Illinoian till in Ohio and that portion of Kentucky which was reached by the till sheet. The most complete fauna occurs at Big Bone Lick on Big Bone Creek, Boone County, Kentucky, twenty miles south of Cincinnati, Ohio. Foster,[145] many years ago, called attention to the position of the fossils as related to the strata. His section is as follows:

Yellow clay, containing remains of bison and deer	15–20 feet
Blue clay, with remains of elephant and mastodon	x

The fauna has been monographed by Leidy[146] and has been referred to by many other authors.[147] From these various sources the fauna is seen to be made up of the following species:

Megalonyx jeffersoni	*Alces americanus*
Mylodon harlani	*Rangifer caribou*

[144] Geol. Surv. Ohio, III, pp. 381-391.

[145] Proc. Amer. Assoc. Ad. Sci., X, p. 161, 1856.

[146] Journ. Phil. Acad., VII, 1869.

[147] Cooper, Smith, and DeKay, Amer. Journ. Sci., (i), XX, pp. 370-372; Smith. Contr. Knowl., V, Art., 3, 1852; VII, Art., 5, 1853.

Equus complicatus (=*americanus*)	*Boötherium bombifrons*
" *fraternus*	*Symbos cavifrons*
Tapirus haysii	*Bison antiquus*
Platygonus compressus	" *bison*
Odocoileus virginianus	*Mammut americanum*
Cervus canadensis	*Elephas primigenius*
Cervalces scotti	*Neotoma magister*
	Ursus americanus

Several horizons are evidently represented at Big Bone Lick, as suggested by Foster and Hay. The lists which have been published do not discriminate and some of the material was undoubtedly secured from a higher level and therefore referable to a later time. Hay[148] believes that the deposit contains animals which have been mired from Illinoian (Sangamon) time to the present. Lyell states[149] that the bison resorted to the springs up to a recent date. He also mentions the presence of fresh water and land shells with the bones, the species being the same as now found in this region. The *Bison bison*,[150] according to Shaler, is found only in the superficial strata and hence referable to a late period, possibly post-Wisconsin. Some of the deer also belong to a later period than the Sangamon. As the different species have not been separated stratigraphically, they have been listed here together for the sake of completeness. *Bison latifrons* was reported by Peale[151] from a small creek about a dozen miles north of Big Bone Lick. It probably belongs to the same age as the other fossils at the previously mentioned locality.

Other vertebrate remains bave been reported from Ohio as follows:

Mammut americanum.	In bank of Raccoon Creek, near Granville.[152] Near Nashport, on gravel, at depth of 14 feet.[153] Muskingham County, in muck 25 feet.
Castoroides ohioensis.	Nashport, below the surface.[154] Also 14 feet below the surface on bed of pebbles and gravel.[153]
Equus species.	"Excavation for outer wall of penitentiary, Columbus."[155]

[148] Geol. Surv. Ind., 36th An. Rep., p. 624.

[149] Amer. Journ. Sci., (i), XLVI, pp. 320-323, 1843.

[150] Allen, American Bisons, pp. 53, 236.

[151] Philos. Mag., XV, pp. 325-327.

[152] Hicks, Amer. Journ. Sci., (iii), V, p. 79. This locality is on the edge of the Wisconsin drift, and the remains may be of later age.

[153] Foster, *op. cit.*, (i), XXXI, p. 80, 1837.

[154] Klippart, Cin. Quart. Journ. Sci., II, p. 154.

[155] *Op. cit.*; the horizon is doubtful, but the inference is that it is Sangamon, as horses have not been found in later deposits.

Ursus procerus.	Overpeck Station,[156] on C. H. and D. Railway, four miles from Hamilton, Butler County, 23 feet below the surface on "nest of petrified sticks."
Ovibos moschatus.	Youngstown, under 60 feet of gravel.[157]

In Jackson and Muskingham counties several deposits occur from which the remains of mammals have been reported. These are in stream deposits evidently laid down by water from the Wisconsin ice. As the deposits containing the bones are at the base of the sections, they may represent Sangamon time.

In Jackson County (Briggs,[157a]) at Salt Creek, in the northwestern part of the county, the bones of an elephant, thot to be *Elephas jacksoni* (=*columbi*) were found. The section of the bank at this locality is as noted below:

1. Yellowish clay	5½ feet
2. Yellowish sandy clay	7½ "
3. Ferruginous sand, partly cemented with iron	4–8 inches
4. Chocolate colored sand or mud, the lower part containing remains of gramineous plants	2 feet
5. Sandy clay, light chocolate colored	1½ "
6. Sand and clay with large proportion of animal matter. Contains fossil bones	1–1½ feet
Height of section	17½–19 feet

Many fossil bones are reported from salt wells in this county, including the elephant and the *Megatherium*.

In Muskingham County (Wyman[157a]) the valley drift of the Muskingham River near Zanesville presents the section noted below:

1. Yellow loam, stratified	8 feet 0 inches
2. Fine sand	1 " 0 "
3. Fine gravel	0 " 6 "
4. Yellow loam	2 " 0 "
5. Pebbles of igneous rocks	6 " 0 "
6. Yellow sand stratified	0 " 6 "
7. Yellow loam	0 " 7 "
8. Pebbles like number 5 with boulders	2 " 6 "
9. Fine yellow sand, with remains of elephant	8 " 6 "
Height of section	29 feet 7 inches

[156] Miller, Proc. Biol. Soc. Wash., XIII, pp. 53-56. Hay (36th An. Rep., p. 775) believes that the deposit may be older than the Illinoian as rock was found 3-4 feet below the bear skull. As the old forest beds in this region are believed to be of Sangamon age it seems logical that this ancient bear lived at the same time.

[157] Hay, 36th An. Rep., Geol. Surv. Ind., p. 641. If the depth of 60 feet is correct it would probably penetrate the Wisconsin drift and the fossil musk ox may belong to the Sangamon fauna.

[157a] Briggs, First An. Rep. Geol. Surv. Ohio, 1838, p. 96. Wyman, Proc. Amer. Assoc. Ad. Sci., X, pp. 169-172, 1857.

The teeth of an elephant (*Elephas primigenius?*) were found in stratum 9 and may possibly be referred to the Sangamon interval.

5. WISCONSIN

Old forest beds are known to occur beneath the Wisconsin till in this state. Alden[158] refers these to the Peorian interval, but they would seem to be equally as logically referred to the Sangamon interval. The Illinoian drift sheet disappears beneath the Wisconsin drift sheet south of Green Bay, and so far as known there are no Iowan drift deposits in the vicinity. If the Iowan ice did not reach this region, it may be that the forest of both the Sangamon and Peorian intervals are represented in these ancient forest beds. Unless the ice was near enough to kill the trees, there is no reason why the forests, especially the coniferous species, could not have existed continuously thru both Sangamon and Peorian time, and until they were destroyed by the Wisconsin ice sheet.

Lawson[159] records many ancient forest beds from the region of the Fox River, in Calumet and Outagamie counties. These forest remains are under from 10 to 100 feet of red till, and are composed of moss, leaves, grasses, seeds, limbs and branches of trees and saplings, many of the trees being 24 inches in diameter. Some of the vegetation with their localities are tabulated below. The names are those given by Lawson.

Name	Locality
Pine cones and logs.	Town of Harrison, Calumet County.
Cedar, black ash, black oak, tamarack	Border of Lake Little Butte des Morts.
Linden (basswood)	Forest Junction, Calumet County.

Lawson says: "All these stumps bear evidence in their ragged heads of the trees having been violently wrenched off. The most notable stump field is that at Lewis Hankey's brick yard in the Town of Neenah, on the west shore of Lake Little Butte des Morts. Here the removal of twelve feet of red clay in brick making has uncovered several acres of stumps still standing and about twelve inches high. The bed of vegetable mould and leaves is here several inches thick and rests on a thin layer of blue clay." This forest bed is more probably postglacial, possibly representing the interval between a retreat and advance of the Wisconsin ice (see p. 118). The forest bed encountered in deep wells in various parts of the Green Bay—Lake Winnebago region is probably of Sangamon age and there is every reason to believe that this deposit underlies a large area of the drift. Several well sections north of Appleton afford ex-

[158] Science, N. S., XXIX, p. 557.

[159] Bull. Wis. Nat. Hist. Soc., II, p. 170, et seq.

amples of the strata in which the forest is found. Some of these are noted below:

Town of Center		Seven miles north of Appleton	
Red clay	15 feet	Clay	7 feet
Sand	80 "	Sand	15 "
Blue clay	25 "	Red clay	40 "
Wood, leaves, stumps	2 "	Gravel	12 "
Gravel	x "	Red clay	6 "
		Trees, leaves, stumps	2 "
Depth of well	122 "	Gravel	10 "
		Rock	x
		Depth of well	92 "

Whittlesey[160] many years ago referred to the same deposit when he described the buried forest of Green Bay at 24 and 50 feet below the surface. Some wood examined was determined as cedar.

A number of instances are on record of the occurrence of wood and old soils beneath Wisconsin till in southern Wisconsin. Both Winchell[161] and Newberry[162] have reported wood "resembling white cedar" from a well 18 feet deep in Walworth County. Winchell reports a "tamarack" log from a depth of 25 feet, with clay above and gravel below, the locality being five miles east of Geneva. At Appleton, Outagamie County, red cedar is reported from 30 feet, also in red clay. In Brown County, wood, apparently willow, was found in red clay, 50 feet below the surface.

The variation in the depth below the surface of these deposits indicates either a great variation in the thickness of the Wisconsin till, or that several horizons are represented. It may also be true that the Wisconsin till contains many sticks and logs at various depths which were picked up by the ice sheet from the Sangamon or Peorian surface and incorporated with the Wisconsin till.

Alden [162a] lists a number of records of vegetal remains from deposits thot to lie between the Illinoian and Wisconsin tills, in southeastern Wisconsin. The variation in depth indicates probably that several drift sheets have been penetrated. The shallower depths evidently record the stage preceding the readvance of the Lake Michigan glacier. For convenience these records are tabulated below:

[160] Foster and Whitney's report, p. 394.
[161] Proc. Amer. Assoc. Ad. Sci., XXIV, pp. 54-55.
[162] Geol. Ohio, II, p. 31.
[162a] Professional paper 106, U. S. G. S., pp. 177-179.

County	Township	Depth	Character
Marquette	Westfield	230	Carbonaceous matter
	Montello	20	Logs
Green Lake	Brooklyn	100	Leaves
Sauk	Delton	260–270	Twigs
	Delton	292	Muck
	Greenfield	190	Muck
Dane	Middleton	100	Peat
	Middleton	92	Wood
	Middleton	80	Black material
	Madison	240	Wood
	Fitchburg	112	Peat
	Fitchburg	135	Muck and driftwood
	Dunkirk	200	Wood
Rock	Harmony	40	Blackish clay
	Harmony	125	Muck
	Johnston	40	Muck
Walwoth	Richmond	230	Black soil
Jefferson	Farmington	60	Wood
Waukesha	Summit	60	Muck
Washington	Hartford	30	Muck
	Addison	30	Soil, tamarack tree
Fond du Lac	Fond du Lac	30–50	Black dirt, wood
	Eden	90	Muck
Walworth	Lafayette	180	Muck
	Bloomfield	98–141	Wood
	East Troy	60	"Iron ore"
Kenosha	Salem	50–60	Gas
Milwaukee	Greenfield	26	Black sand
	Franklin	24	Black loam
	Oak Creek	114	"Dry turf"
Waukesha	Lisbon	50	Black soil
Washington	Polk	180	Muck or peat
Washington	Jackson	250	Black peat
Sheboygan	Holland	60	Muck
	Holland	100	Black muck and leaves
	Holland	62	Black muck

Weidman[163] finds evidences of five drift sheets in Wisconsin—the pre-Kansan, Kansan, Iowan, Early and Late Wisconsin. An interglacial interval is noted between the second and third drifts, i.e. the Sangamon. The loess is considered later than the third (Iowan) and older than the fourth (post-Iowan or Peorian). Much interesting and valuable information awaits the student

[163] Science, N. S., XXXVII, p. 456.

who will take the trouble to study and classify the material in these buried forests. There should also be found with the vegetation a varied fauna of mollusks and insects, as well as vertebrates.

6. MINNESOTA

Upham has recognized the Sangamon interval in Minnesota, tho no evidences of life are mentioned. The location of this stage is thus described.[164] "Three chains of lakes on the till area of Martin County, one of the central counties of the southern tier in Minnesota, adjoining Iowa, are ascribed to interglacial erosion of rivers flowing south, where now the courses of drainage pass eastward. The duration of this interglacial stage is estimated by Winchell, from changes of the course of the Mississippi River in and near the Twin Cities of Minneapolis and St. Paul, to have been about 15,000 years. It seems to be represented in the history of the Quaternary lakes Bonneville and Lahontan by the stage of their desiccation between their previous prolonged stage of high water and their ensuing higher but more brief rise of water; and it is correlated with the Sangamon interglacial stage between the Illinoian and Iowan stages of glaciation. Its time is estimated to have been approximately from 40,000 to 25,000 years ago."

7. MICHIGAN

It is believed[165] that the older drift sheets extended over Michigan, the Kansan from Keewatin and the Illinoian from Labrador. Beds of muck and peat have been found between drift sheets in deep borings as far north as Hopkins in Allegan County, and near Shelby in Oceana County. These occur at a depth of about 150 feet. It is not definitely known whether the overlying drift includes the Iowan or is exclusively Wisconsin. At Ann Arbor borings struck a much harder sheet of till than the Wisconsin in the lower part of the till. The harder till is probably Illinoian. Its thickness at Ann Arbor is 30-40 feet, but north of Ypsilanti it is 200 feet thick.

In a later publication[166] Leverett refers certain old soils to the post-Illinoian stage. These references include several mentioned above. The specific localities are:

Near Avoca, St. Clair County.
East Fremont, Sanilac County.
Near Hillsdale, Hillsdale County.
Near Allegan, Allegan County.
West of Shelby, Oceana County.

[164] Science, N. S., XXXVII, p. 457; Int. Geol. Congress, 12th session, Canada, 1913, pp. 1-11. Many of the strata mentioned are referred in the present work to the Yarmouth interval. See page 262.

[165] Leverett, 6th An. Rep., Mich. Acad. Sci., p. 105.

[166] Mich. Geol. Biol. Surv., Geol. Ser., No. 7, pp. 53-54.

In Bay County a number of coal shafts penetrate several tills and interglacial deposits.[167] These are tabulated below:

Near Amelith. Shaft of Pittsburg Coal Co.
Soil deposit at 110 feet, underlaid by beds of sand and gravel and overlaid by clay drift of Wisconsin age.

Shaft of Hecla mine, northeastern part of Frankenlust Township.
Fragments of trees in beds of sand just above the bed rock, at a depth of 85 feet. This vegetal deposit is probably contemporaneous in age with the 110 foot bed near Amelith, which may be Sangamon.

Section 19, Bangor Township.
Vegetation at 80 feet, underlaid by 37 feet of boulder clay.

In the old Monitor shaft (S.E. ¼ Sect. 28, T. 14 N, R. 4 E.) at a depth of 45 feet a vegetal deposit was found.

Section of Monitor Shaft

1. Clay	45	feet
2. Upper Monitor soil	4½	"
3. Clay	31½	"
4. Sand, lower Monitor soil	10	inches

The upper Monitor soil contains impressions of leaves, twigs, etc. Just what relation the two clays and the two soils bear to the intervals beyond the Wisconsin is not clear. If there was an Iowan drift in Michigan number 3 might be this one; or it might be early Wisconsin drift. The stratigraphical position of these deposits is not yet clear.

At two localities in the Upper Peninsular, one near Hessel and the other in the region about Isabella, to the north of Big Bay de Noc, there are deposits of fine, pink, thinly laminated, highly plastic clay which as shown by its fineness and evenness of bedding was laid down in a large water body.[168] Similar clay is perhaps present at other localities in the same general region, concealed beneath deposits of sand and possibly of till, but evidence in this connection is at present wanting. Of these deposits Russell says, "The deposits of clay briefly described above, are of the same character as much larger deposits exposed near Sault Ste. Marie and occurring widely on the Lake Superior shore of Michigan. Judging from the pronounced physical characteristics of the clay at these several localities and its known relation to other and associated deposits, it seems evident that it was laid down in a single widely extended water body. No fossils have been found in it to show whether it is of marine or lacustrine origin, but the presumption is that it was deposited in a lake. As to the date at which this lake existed no good evidence has as yet been obtained in Northern Michigan, but during the past summer similar clay previously known to exist in the northern portion of southern Michigan has been shown

[167] Cooper, Rep. State Board Geol. Surv., 1905, pp. 152, 340, 341.

[168] Russell, Rep. Geol. Surv. Mich., 1904, pp. 93-94.

by Frank Leverett to be several hundred feet thick and of older date than the surface morainal deposits of the region and to rest upon older glacial deposits. It is thus shown to have been deposited previous to the southward advance of the Wisconsin ice sheet. This is a highly instructive discovery, and if as now seems probable, the pink clays of northern Michigan were deposited in the same lake as the similar clays in southern Michigan, the existence of an inter-glacial lake in the Great Lakes basin of comparable size with Lake Algonquin is made manifest." These clays may be of Sangamon age.

Sherzer[169] mentions Illinoian drift in Monroe County with "coal" (probably compacted peat) above drift; and Davis[170] mentions pre-Wisconsin drift in Tuscola County. Many years ago[171] Wm. Logan recorded the presence of a deposit 12-14 feet thick, containing roots and limbs of trees, at Grand Sable, south shore Lake Superior. The deposit rested on bluish-drab clay and was overlaid by a bed of sand interstratified with gravel 300 feet in thickness. It is not known what interval the vegetation may represent.

Taylor[171a] states that pre-Wisconsin till occurs beneath the Wisconsin drift in the area of the "Thumb" in Michigan. Of this deposit Taylor says: "Till older than that deposited by the Wisconsin ice sheet seems to underlie more or less continuously all of the later or Wisconsin drift in Indiana and the southern peninsula of Michigan." Old soil in places overlies this older drift.

8. NEW YORK

Evidence is accumulating, indicating the presence of a till sheet beneath the Wisconsin drift sheet. Just which drift sheet is represented has not been definitely stated, but it is apparently referable to the till beneath the interglacial deposits at Toronto, which is thot to be the Illinoian stage. In the Keuka Valley, wave cut terraces have been observed which are believed to have been produced by a pre-Wisconsin glacial lake.[172] In the Finger Lake region of New York a pre-Wisconsin drift has also been detected.[173] In the Mohawk Valley[174] the hardpan referred to in the well sections evidently represents the Illinoian till sheet.

Well borings in western New York indicate that several drift sheets have crossed the state. Spencer[175] has published a well section taken in the Whirlpool-Saint Davids gorge, Niagara River, which exhibits several tills and interglacial deposits.

[169] Geol. Surv. Mich., VII, part 1, pp. 126-127.

[170] An. Rep. Geol. Surv. Mich., 1908, pp. 121-358.

[171] Geol. of Canada, 1863, p. 905.

[171a] Mon. LIII, U. S. G. S., pp. 261, 289.

[172] Carney, Amer. Journ. Sci., (iv), XXIII, pp. 325-335, 1907.

[173] Carney, Denison Univ. Bull., XIV, pp. 3-18, 35-46, 1908.

[174] Brigham, Bull. Geol. Soc. Amer., IX, pp. 189-190. See also Fairchild, Bull. Geol. Soc. Amer., XX, p. 632.

[175] Bull. Geol. Soc. Amer., XXI, p. 436, 1910.

Possible correlation	*Character of deposit*	*Feet*	*Total*
Wisconsin till 1	Reddish clay with few pebbles and glaciated stones	40	40
Wisconsin till 2	Rounded gravel (2 feet) over light brownish fine, sandy loam, which is also calcareous (38 ft.)	40	80
Wisconsin till (Early) 3	Small angular to rounded gravel mostly quartzite, in red clay matrix, (4 feet); loam with gravel as above (10 feet); angular gravel with little clay binding (26 feet)	40	120
Wisconsin till (Early) 4 (Iowan?)	Bluish clayey sand with angular fragments (boring here was rapid with admixture of recovered materials)	66	186
Interglacial Land surface Sangamon (Scarboro beds) 5	Six inches of fine white sandy soil, deoxidized, with twigs and a well preserved trunk of a northern white spruce. It rests on a grayish clayey sand, which, when the calcareous and ferruginous matter are removed, is similar to the deoxidized soil above. Also contains twigs	34	220
Interglacial Scarboro beds 6	Angular and subangular gravel, mostly quarztite, size of peas, with some earthy binding materials in variable layers. At 16 feet below the top was brown rusty sand (indicating an interglacial surface) strongly magnetic. At 15 feet the fragments were large, subangular at base	23	243
Interglacial Don beds ?	Loamy sand with quartzite pebbles, which at base are rounded	16	259
Interglacial (Sangamon) Don beds ?	Very fine siliceous flour, somewhat calcareous, but very rich in magnetic sand. Deposit held water, flowed upward in casing for 8 feet, like cement, and stopped the boring	9½	268½
Interglacial or glacial	To more than	24½	293
(Probably Illinoian till)	This is the level of the whirlpool but the drift may continue for 50 or 100 feet, less or more	50	

Spencer refers the wood in stratum 5 to the Scarboro beds at Toronto[176] and this correlation appears to agree with the evidence. The above interpretation of the well section strata may not be correct but it appears to be in conformity with the evidence, as compared with the section at Toronto. Kindle and Taylor[177] do not name the drift sheet beneath the Wisconsin, nor do they discuss this well section.

An interglacial fauna of possible Sangamon age has been observed at the south end of Cayuga Lake.[178] This deposit is on the west shore of the lake, "between Taughannock Falls and Frontenac Beach in a small ravine which

[176] *Op. cit.*, p. 438.
[177] Niagara Folio, p. 9.
[178] Maury, Journ. Geol., XVI, pp. 565-567.

has cut through one of the delta terraces so common in Cayuga Valley." A vertical section is shown below:

Drift	20–30 feet
Gravel and sand	several inches.
Fossiliferous clay	5–8 feet.
Boulder clay	10–15 feet.
Devonian shales	10 feet above lake level.

The lower boulder clay probably representing the Illinoian till, is oxidized, indicating a period of erosion. The fossils, mostly mollusks, are imbedded in a slaty blue clay, loose and peaty at the base, but becoming more compact toward the center and upper parts. The lower, peaty deposit is composed almost wholly of plant remains. These have not yet been identified owing to their very imperfect state of preservation. It would be of great interest to compare these plants with those found at Toronto in supposedly equivalent beds. The mollusks obtained from this deposit have been determined as follows:

x *Anodonta grandis*
  " *grandis footiana*
  " *marginata*
x *Lampsilis luteola*
x " *ventricosa*
x *Sphaerium sulcatum* (=*simile*)
x *Pisidium compressum*
  " *virginicum*
x *Campeloma decisum*
x *Valvata tricarinata*
x *Amnicola limosa*
x *Physa heterostropha*
x *Planorbis antrosus* (=*bicarinatus*)
  " *deflectus*
  " *lentus* (=*trivolvis*?)
x " *parvus*
x *Galba elodes*
  " *palustris*

Comparing the above list with the Don beds at Toronto, we find that 12 species out of 18, or two-thirds, are common to both localities (an x in the above list signifies that the species is found in the Don beds). The difference is purely one of habitat, the Cayuga Lake deposit representing the quieter waters of a lake, such as the Cayuga of today, while the Toronto mollusks lived on the shores of, or in an estuary near the rougher waters of the ancient Lake Ontario. It is interesting to note that at the present time all of the above species are living in Cayuga Lake.

Rich and Filmer,[178a] in a study of the gorge of Six Mile Creek, near Ithaca, find evidences of three glacial stages and two interglacial intervals. Their interpretation includes (pages 73-74):

1. Preglacial time.
2. First glacial epoch.
3. First interglacial epoch.
4. Second glacial epoch.
5. Second interglacial epoch.

[178a] Journ. Geol., XXIII, pp. 59-80, 1915.

6. Third glacial (Wisconsin) epoch.
7. Post-Glacial time.

Number 3 may be of Yarmouth age and number 5 of Sangamon age; or these may be respectively of Sangamon and Peorian age. Number 5 might also be an interval between older and later Wisconsin time. Tarr's section from artesian well borings in Ithaca may include some of the strata mentioned above (see page 149).

Of Sangamon land surfaces there is but little evidence. In the Watkins Glen-Catatonk Folio,[179] reference is made to an older drift in Watkins Glen, underlying 100 feet of Wisconsin drift. In the blue clay underlying the drift and overlying a bed of sand and gravel, the leaf of an Arctic willow (*Salix reticularis*) was found. This deposit is thot to have been laid down during the advance of the Wisconsin ice, and the willow adds additional weight, as it represents a cold climate.

The remains of a mastodon, together with vegetation, were found in pot holes in the bed rock at Cohoes, Albany County, beneath the drift. These are at least as old as the Sangamon, if indeed, they are not of greater age. Six species of trees are represented.[180]

Pinus strobus	*Larix americana* (=*laricina*)
Picea canadensis	*Acer rubrum*
" *nigra* (=*mariana*)	*Betula alba*

A beaver dam with beaver cut sticks was also observed.

Many years ago[181] a fox (*Urocyon cinereoargentatus*?) was reported from Broome County "in fine clay beneath drift, in elevated ground which separated the upper courses of the rivers Delaware and Susquehanna near the line which divides New York and Pennsylvania." The bones were found 40 feet below the surface at a point 1375 feet above tide. The deposit appears referable to the Sangamon interval.

A tusk of a proboscidian, probably of *Mammut americanum*, was found recently in a gravel pit in Pony Hollow, twelve miles southwest of Ithaca.[181a] The deposit was stratified sand in a terrace "whose top follows the valley wall above the outwash gravel plain which occupies the floor of the valley. The exact origin of this Pleistocene terrace is obscure but it is certainly not later than the end of the occupation of the valley and may be earlier." It is possible that this terrace may be post-Illinoian and the tusk of Sangamon age.

[179] U. S. G. S., Atlas No. 169, p. 26.
[180] Amer. Journ. Sci., (ii), XLIII, pp. 115-116, 1867.
[181] Redfield, Proc. Amer. Assoc. Ad. Sci., 2nd Meeting, 1850, pp. 255-256.
[181a] Sheldon, Science, N. S., XLI, pp. 98-99.

In Allegheny County, at Angelica, on the Genesee River, parts of trees have been observed beneath tough, firm clay, several yards below the surface.[182] This is near the margin of the Wisconsin drift sheet and possibly represents either a Sangamon or a Peorian soil horizon.

Steller[182a] recognizes an interglacial interval in his study of the Saratoga Quadrangle. Of this he says: "In the region within which is included the area of the Saratoga Quadrangle the glacial period, or Ice Age, was broken by at least one interglacial epoch. This deduction is made from the fact that the Hudson River in its course across the southeastern spur of the Adirondack Mountains occupies an indubitably geologically recent valley of trench-like form and yet one that is cut in till."

Fairchild[183] also recognizes the possibility of a pre-Wisconsin ice invasion of New York, and says: "The accumulating evidence of more than one glacial epoch in New York adds force to the thought that some of the peculiar relief features of the region have been produced by multiplicity of glaciation and glacial drainage. The lowland of St. Lawrence Valley and east of Lake Ontario exhibits many anomalous features which harmonize with this view." It would seem, therefore, that the presence of a pre-Wisconsin ice sheet, probably Illinoian separated from the later drift sheet (Wisconsin) by an interglacial interval (probably the Sangamon), is clearly indicated in New York State.

9. NEW ENGLAND STATES

One or more interglacial intervals are represented in New England. Near Brandon, Vermont, 50 feet below the surface, lignite was found and was said to be covered by a true drift.[183a] In Maine, New Hampshire, and Massachusetts the complexity of the glacial deposits has been recognized and an effort has been made to correlate the New England divisions with those of the Mississippi Valley. All of the till sheets, as well as the interglacial intervals, are recognized.[184] These are mostly of marine origin and need not be considered here.

In the Connecticut Valley there are certain phenomena which represent either interglacial intervals or prolonged oscillations of the Wisconsin ice front. Emerson says:[185] In the long cutting of the canal railroad extension near the camp meeting grounds on the north line of Northampton, the interlocking of the till and sand deposits showed clearly that the ice after receding from this

[182] Tomlinson, Amer. Journ. Sci., (i), XXIII, p. 207.

[182a] Bull. N. Y. State Museum, No. 183, pp. 1-50. Also Bull. No. 45, pp. 1-194.

[183] Bull. N. Y. State Museum, No. 160, p. 18.

[183a] Thompson, Proc. Bost. Soc. Nat. Hist., 1851, pp. 33-34.

[184] Clapp, Bull. Geol. Soc. Amer., XVIII, pp. 505-556. Correlation table opposite page 512. References are given to other works on New England glacial deposits.

[185] Holyoke Folio, p. 7.

point in the valley twice readvanced over it." At this point a section exhibits the following strata:

Drumlin peak, X.
Beach sands, 12–15 feet. First interval of recession.
Fine layer of till, 4–5 feet. First readvance of ice.
Sands of high terrace type, 22 feet. Second interval of recession.
Till, 8 feet. Second readvance of ice.
Coarse, cross-bedded sands, x. Third recession of ice.

This section is 40 feet thick and the strata may be seen for upwards of half a mile from north to south. Comparing this data with the paper of Clapp[184] it would seem to fit in with the general classification of glacial tills and interglacial intervals. No biotic remains have been observed in the sands between the tills.

Somewhat recently, excavations in the City of Boston have uncovered strata apparently referable to one or possibly two drift sheets of pre-Wisconsin age.[185a] The evidence for these "consists of a zone of extremely weathered material beneath the Wisconsin drift, an erosion unconformity, different types of deposits, a slight trace of an interglacial soil, some interglacial subsoils, and an apparent difference in the direction of the source of included debris. It was possible to determine with some accuracy the zone of post-Wisconsin oxidation, and the final shaping of the ridge in which this evidence was found appears to be due to the readvance of an ice sheet which slightly contorted the uppermost water lain materials. The axis of this ridge is accordant with the direction of the striae of the last glacial advance in the region."

As is the case in New York State, evidence is accumulating which indicates complexity in the glacial deposits of the New England States; and it will probably be found that several of the ice sheets overran this territory and were separated by interglacial intervals correlative with those of the areas farther west.

10. CANADA

a. *The Toronto Formation*

The most complete interglacial biota at present known is contained in the sands and clays at Toronto, Ontario. These are placed by Coleman[186] in the

[185a] Wentworth, Science, N. S., XLII, p. 58.

[186] Interglacial Periods in Canada, pp. 12-14. Coleman later (Bull. Geol. Soc. Amer., XXVI, pp. 243-254) refers these fossil remains to the Aftonian interval. The fauna is, however, more like that of the Yarmouth or Sangamon. The complexity of the upper drift deposits seems referable to the fluctuations of the ice fronts of later ice sheets. The Aftonian contains a number of extinct mammals which are absent from the Toronto formation, and the position of the Toronto deposits with relation to the old soils and other interglacial phenomena of adjacent regions, seems to place it rather in the Sangamon Interglacial interval.

post-Illinoian or Sangamon interval. The Toronto beds exhibit the following section (figure 5):

Boulder clay number 4	48	feet
Stratified sand overlying stratified clay	36	"
Boulder clay number 3	32	"
Silty sand, upper layers crumpled	25	"
Boulder clay number 2	9	"
Cross-bedded sand	29	"
Boulder clay number 1	24	"
Fossiliferous sand } Scarboro beds	59	"
Peaty clay } Scarboro beds	92	"
Below Lake Ontario (Don beds)	35	"
Boulder clay (Illinoian till)	x	"
Hudson River shales	x	"
Height of section	389	"

After the Illinoian invasion, the ice must have receded in much the same manner as during the Wisconsin waning, forming lakes comparable to glacial

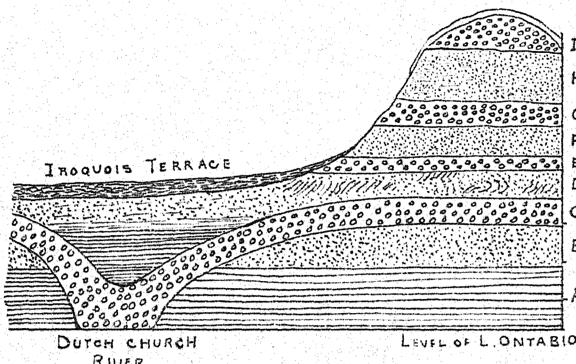

Figure 5. Section of strata at Scarboro Heights, near Toronto, Ontario.

I I.	Boulder clay number 4	48 feet,	354 feet above the lake
H II.	Stratified sand overlying stratified clay.	36 feet,	306 " " " "
G III.	Boulder clay Number 3	32 feet,	270 " " " "
F IV.	Silty sand the upper layers crumpled	25 feet,	238 " " " "
E V.	Boulder clay number 2	9 feet,	213 " " " "
D	Cross-bedded sand	29 feet,	204 " " " "
C	Boulder clay number 1	24 feet,	175 " " " "
B	Fossiliferous sand	59 feet,	151 " " " "
A	Peaty clay	92 feet,	92 " " " "
	Level of Lake Ontario	x	x

The Iroquois terrace and the bed of the old Dutch Church River are also shown (After Coleman, Bull. Geol. Soc. Amer., X, figure 4).

lakes Whittlesey, Warren, Iroquois, and possibly including other series of lakes in the west, like Algonquin and Nipissing. The level of this interglacial

lake was at first about that of the present Lake Ontario (possibly somewhat lower), but later rose to 60 feet (Don beds) and finally to 150 feet above the present level (Scarboro beds). This change of level was due probably to the rising of the outlet at the east end of the Ontario basin (differential elevation).

Previous to the formation of the Don beds the underlying Illinoian boulder clay had been eroded by streams to a depth of 15 feet (the lower portion being in shale rock). A rich forest of deciduous and coniferous trees had also migrated northward, and the mammoth, mastodon, and bison roamed the country. The great variety of this forest covering is indicated by the number of species of plants which have been found in this deposit. These are listed below:

Acer pleistocenicum	*Ostrya virginica*
" *spicatum*	*Picea nigra* (=*mariana*)
" *torontonensis*	" species
Asiminia triloba	*Pinus strobus*
Carya alba	*Platanus occidentalis*
Cercis canadensis	*Populus balsamifera*
Chamaecyparis sphaeroidea (=*thyoides*)	" *grandidentata*
Chara species	*Prunus* species
Clethra alnifolia	*Quercus alba?*
Crataegus punctata	" *acuminata* (=*muhlenbergerii*)
Cyperaceae species	" *macrocarpa*
Eriocaulon species	" *oblongifolia*
Fraxinus americana	" *obtusiloba* (=*stellata*)
" *sambuciformis* (=*nigra*)	" *rubra*
" *quadrangulata*	" *tinctoria* (=*velutina*)
Festuca ovina	*Robinia pseudo-acacia*
Gleditsia donensis	*Salix* species
Hippuris vulgaris	*Taxus canadensis*
Hypnum species	*Thuja occidentalis*
Juniperus virginiana	*Tilia americana*
Larix americana (=*laricina*)	*Ulmus americanus*
Maclura aurantiaca (=*pomifera*)	" *racemosa*
	Vaccinium uliginosum

Of the above species three are extinct, *Acer pleistocenicum*, *A. torontonensis*, and *Gleditsia donensis*. The waters of the interglacial lake teemed with mollusks, over 40 species having been recorded, as noted below:

Pelecypoda	Gastropoda
Fusconaja undata (=*trigona*)	*Campeloma decisum*
" *solida*	*Pleurocera elevatum*
Crenodonta undulata	" *elevatum lewisii?*
Quadrula pustulosa	" *subulare*
" *pustulosa schoolcraftensis*	*Goniobasis depygis*
Pleurobema coccineum	" *haldemani*
" *pyramidatum*	*Somatogyrus isogonus*
" *clava*	*Amnicola limosa*

Elliptio gibbosus	*Amnicola limosa porata*
Anodonta grandis	" *emarginata* (=*obtusa*)
Ptychobranchus phaseolus	" *cincinnatiensis* (=*sayana*)
Eurynia recta	*Valvata tricarinata*
Lampsilis luteola	" *sincera*[187]
" *ventricosa*(=*occidens*)	*Physa ancillaria*
Sphaerium sulcatum (=*simile*)	" *heterostropha*
" *rhomboideum*	*Planorbis bicarinatus* (=*antrosus*)
" *striatinum*	" *parvus*
" *solidulum*	*Galba elodes*
Pisidium adamsi	" *obrussa* (=*desidiosa*)
" *compressum*	*Succinea avara*
" *noveboracense*	*Bifidaria armifera* (=*armata*)

Several cyprids and beetles (mostly wings) have also been obtained from these beds. The mammoth or mastodon, the bison and a fish comprise the vertebrate fauna.

A study of the biota of the Don beds suggests (as previously stated by Coleman and Penhallow) that during the Sangamon interval a warm climate prevailed in this region, as warm or warmer than the present, perhaps like that of southern Ohio or Pennsylvania. Such plants as the paw-paw (*Asiminia triloba*), the osage orange (*Maclura aurantiaca*), as well as species of maple, ash, oak, hickory, elm and basswood, indicate a genial climate. (See Penhallow, Trans. Roy. Soc. Can., X, page 67, 1904). The unionid molluscan fauna also indicates the same thing. Three species, *solida*, *clava*, and *pyramidata* do not now live in the St. Lawrence drainage, being confined to the Ohio and Mississippi valleys, farther south. Four species, *phaseolus*, *coccineum*, *pustulosus*, and *undata* still live in Lake Erie, but not in Lake Ontario. The other species are now common in Lake Ontario and tributary streams. Of the gastropods, *Pleurocera elevatum lewisii* and *Goniobasis depygis* do not now live in the Ontario basin. The molluscan fauna is strongly indicative of the Mississippi Valley region, all of the species enumerated being found at the present time within its borders. The postglacial origin of the fluviatile biota, therefore, must have been in this region, where they had been crowded by the Illinoian ice invasion. From here, via an outlet at Chicago or perhaps one at the western end of Lake Erie (like the Fort Wayne outlet) the aquatic life returned and repeopled the devastated territory.

Immediately above the Don beds is a deposit of stratified, peaty clay, 92 feet in thickness, the thin sheets of peaty material, mixed with mica scales, occurring every inch or two. These peaty layers, which may well represent annual floods, when a Laurentian river from Georgian Bay built up a delta of clay and sand in Scarboro Bay extending to the north, and communicating with

[187] Simpson (Proc. U. S. Nat. Mus., XVI, p. 593) says of this species "remarkably depressed"; it probably should be referred to *Valvata bicarinata perdepressa*. *Pleurocera pallidum?* is mentioned by Simpson, but does not appear in Coleman's lists.

a large lake 150 feet higher than the present Lake Ontario, contain the remains of the largest single fossil insect fauna at present known, embracing 31 genera and 72 species. The late Dr. S. H. Scudder enumerates the following species:[188]

Family Carabidae

Elephrus irregularis	*Pterostichus fractus*
Loricera glacialis	" *destructus*
" *lutosa*	" *gelidus*
" *exita*	" *depletus*
Nebria abstracta	*Badister antecursor*
Bembidium glaciatum	*Platynus casus*
" *haywardi*	" *hindei*
" *vestigium*	" *halli*
" *vanum*	" *dissipatus*
" *preaeteritum*	" *desuetus*
" *expletum*	" *harttii*
" *damnosum*	" *delapidatus*
Patrobus gelatus	" *exterminatus*
" *decessus*	" *interglacialis*
" *frigidus*	" *interitus*
Pterostichus abrogatus	" *longaevus*
" *destitutus*	*Harpalus conditus*

Family Dytiscidae

Coelambus derelictus	*Hydroporus inanimatus*
" *cribrarius*	" *inundatus*
" *infernalis*	" *sectus*
" *disjectus*	*Agabus perditus*

Family Gyrinidae

Gyrinus confinis

Family Hydrophilidae

Cymbiodyta exstincta

Family Staphylinidae

Gymnusa absens	*Lathrobium frustum*
Quedius deperditus	*Oxyporus stiriacus*
Philonthus claudus	*Bledius glaciatus*
Cryptobium detectum	*Geodromicus stiricidii*
" *cinctum*	*Acidota crenata* (var. *nigra*)
Lathrobium interglaciale	*Arpedium stillicidii*
" *antiquatum*	*Olophrum celatum*
" *debilitatum*	" *arcanum*
" *exesum*	" *dejectum*
" *inhibitum*	

Family Chrysomelidae

Donacia stiria	*Donacia pompatica*

[188] Contr. to Can. Pal., 1895. See also bibliography at end of this volume.

Family Curculionidae

Erycus consumptus
Anthonomus eversus
" *fossilis*
" *lapsus*
Orchestes avus
Centrinus disjunctus

Family Scolytidae

Phloeosinus squalidens

The plants first observed in the Scarboro beds number over a dozen species, as noted below:

Abies balsamea
Alnus species
Carex aquatilis
" *reticulata*
Equisetum species
Fontinalis species
Hypnum commutatum
Hypnum revolvens
(=*Drepanocladus intermedius*)
* *Larix americana*
Lycopodium species
Oxycoccus palustris
Picea alba (=*canadensis*)
* *Salix* species
* *Vaccinium uliginosum*

Later,[188a] Coleman adds seven species of plants from the Scarboro beetle beds. The plants were identified by W. L. McAtee.

Scirpus fluviatilis
Potamogeton species
Ceratophyllum demersum
Polygonum species
Chenopodium species
Brasenia purpurea
Prunus cf. *pennsylvanicus*

The plant and beetle remains indicate a period when the climate was much colder, like that of Labrador, perhaps, cold and wet. It is to be noted that the rich fauna of the warm temperate climate has mostly disappeared the species being replaced by those able to withstand the rigors of a cold-temperate winter. Only three species of plants are common to both deposits. These are indicated in the above list by an *. All but two of the 72 species of beetles are extinct, a significant fact, indicating that this group of animals has not yet reached a static condition, but is now passing thru a period of active evolution. The great number and variety of species now living also indicates the same condition.

The peaty clay is covered with 59 feet of stratified sand, containing a few mollusks, trees, and vertebrates, which have been identified as follows:

Trees

Abies balsamea
Larix americana (=*laricina*)

Mollusks

Sphaerium fabale
" *rhomboideum*
Valvata tricarinata
Planorbis species
Lymnaea species

[188a] Bull. Geol. Soc. Amer., XXVI, p. 247.

Vertebrates

Mammoth	*Bison bison*
Mammut americanum	*Rangifer caribou*

These beds were apparently laid down in a shallowing lake where the waves formed sand flats and bars, and where an interglacial river Humber from the west brot down sand and gravel. The shells occur in the upper layers.

Following the period of the cold temperate climate the lake fell and the beds were eroded by three interglacial streams, situated near Rough Creek, Highland Creek, and in the Dutch Church Valley. At a later period the entire region was successively covered by three till sheets, representing, probably, the early and late Wisconsin invasions.

The Sangamon interval appears to be represented near Hamilton, at the west end of Lake Ontario. Excavations made in Hunter Street, of that city, revealed the bones of an elephant and pieces of wood at the base of a blue till referred to the Iowan stage, but more probably representing the earlier Wisconsin till. About a mile to the west of this section mammoth tusks and bones were found at a depth of 45 feet beneath hardpan.

In certain sand pits in western Toronto,[189] near Christie and Shaw streets, there are interglacial deposits of cross-bedded sand and gravel laid down by powerful currents. In these beds the bones of *Bison*, *Cervalces*, *Mastodon* and *Elephas*, as well as ivory and a few shells, have been found. The relations of these sands to the other beds are uncertain, but they are doubtless interglacial and are probably correlative with the upper Scarboro beds. The *Cervalces* has been described as *C. borealis*.

b. *Other Canadian Deposits*

Interglacial deposits occur in various places along the Canadian shore of lakes Erie and Ontario. Strata of this age have been studied at Port Rowan, Norfolk County; Brosiville, Leeds County; Prescott, Greenville County; and Cornwall, Stormont County. A generalized section is shown below.[190] (This section applies especially to the Ontario peninsula).

Possible correlation	Formation
Postglacial	1. Clay and sand with gravel near the summit; contains Macoma.
Wisconsin till.	2. Boulder clay.
Sangamon interval.	3. Arenaceous and silty beds. 4. Gray, partially oxidized, brownish clay, thinly stratified, sandy in spots. The Sangean clay. 5. Stratified, bluish-gray clay. The Erie clay, with fossils.

[189] Faull, The Natural History of the Toronto Region, Ontario, Canada, p. 72.
[190] Chalmers, Can. Geol. Surv., Rep., 1901, pp. 167-168 A, 1905.

Illinoian till.	6. Boulder clay, usually a thin sheet.
	7. Decomposed rock in situ.
	8. Surface of fundamental rock.

The Iowan till does not appear to be present in this part of the country. The following fossils have been secured from number 5 of the section.

Campeloma species
Succinea obliqua (=*ovalis*)
Polygyra thyroides

In the vicinity of Lake Simcoe, Ontario, two till sheets occur, separated by stratified sand, gravels, and clays. The lower till is only exposed in the beds of streams where it is seen to be composed of hard, compact sandy clay till without stratification and with polished and striated boulders. Some of the best sections are in the bed of Lovers Creek, about one mile east of Allendale. The upper till in places forms but a thin veneer over the interglacial sands and gravels.[191]

On the Hudson Bay slope interglacial deposits occur on Moose River, fifty miles from the mouth, and at the foot of Long Portage, Missinabi River, a tributary of the Moose. The first deposits are lignitic, the second coarse peat. Penhallow[192] records the following plants from these strata.[193]

Larix americana (=*laricina*). (1)
Picea nigra (=*mariana*). (2)
Distichium capillaceum (=*Dichelyma capillaceum*) (2)
Hypnum recurvans (2)
Lycopodium species (2)

South of James Bay a number of interglacial deposits have been observed, but it is not known whether they are referable to the Peorian or to the Sangamon interval. These are briefly described below:[194]

(1) Beds of lignite on Kenogami River in the bottom of an old channel excavated in the till and again filled by boulder clay. The bed contains sticks of coniferous wood and of the canoe birch. No animal remains have been noted.

(2) In the bank of Coal Brook, three-fourths of a mile from its junction with the Missinabi River. The bed is three feet thick, and is underlaid by soft sticky blue clay and overlaid by 70 feet of till full of small pebbles passing into gravel at the top.

(3) Nineteen miles below Coal Creek on the Missinabi River, there is a seam of lignite 1½–2½ feet thick, made up of sticks and rushes; 80 feet of

[191] Johnston, Can. Geol. Surv., Summary Rep., 1912, p. 299, 1914.
[192] Trans. Royal Soc. Can., X, pp. 56-76, 1904.
[193] (1), Moose River locality; (2), Missinabi locality.
[194] Bull. Geol. Soc. Amer., IX, pp. 385-386, 1898.

yellow weathered gray clay lies below and 45 feet of blue clay is above this bed; both beds are filled with pebbles.

(4) Three miles below Woodpecker Island and nine miles above the mouth of Opazatika River, there is a bed of lignite, 6 feet thick (diminishing to westward) made up of mosses and sticks in shale-like form. A section is shown below:

Hard drab clay, with striated pebbles and boulders	10 feet
Parti-colored clay, with marine fossils	5 "
Lignite	6 "
Clay and lignite	1 "
Unstratified drift	40 "
Depth of section	62 "

Interglacial strata have been noted in Nova Scotia,[195] but no biotic material has been observed. Three glacial and two interglacial periods are indicated but not named.

III. Systematic Catalog of the Biota of the Sangamon Interglacial Interval

PLANTS

BRYOPHYTA

Fontinalaceae

Fontinalis species

Dichelyma capillaceum (L.) Schimp.

Hypnaceae

Sematophyllum recurvans (Michx.) E. G. Britton
Drepanocladus intermedius (Lindb.) Warnst.
Hypnum (?) *commutatum* Hedw.

Characeae

Chara species

PTERIDOPHYTA

Equisetaceae

Equisetum species

Lycopodiaceae

Lycopodium species

SPERMATOPHYTA

GYMNOSPERMAE

Taxaceae

Taxus canadensis Marsh

Taxus minor (Michx.) Britton

[195] Prest, Proc. and Trans. Nova Scotia Inst. Sci., IX, pp. 158-170.

Pinaceae

Pinus strobus L.
Abies balsamea (L.) Mill.
Larix laricina (DuRoi) Koch.
Thuja occidentalis L.
Picea canadensis (Mill.) BSP.
" *mariana* (Mill.) BSP.
Juniperus virginiana L.
Chamaecyparis thyoides (L.) BSP.

ANGIOSPERMAE

Monocotyledoneae

Najadaceae

Potamogeton species

Graminae

Festuca ovina L.

Cyperaceae

Carex aquatilis Wahlenb.
Scirpus fluviatilis (Torr.) Gray
Carex reticulata

Eriocaulaceae

Erieocaulon species

Dicotyledoneae

Salicaceae

Salix species
Populus grandidentata Michx.
" *balsamifera* L.

Ceratophyllaceae

Ceratophyllum demersum L.

Juglandaceae

Carya alba (L.) K. Koch

Betulaceae

Ostrya virginiana (Mill.) K. Koch
Betula alba L.
Alnus species

Fagaceae

Fagus grandifolia Elrh.
Quercus alba L. (?)
" *macrocarpa* Michx.
" *rubra* L.
Quercus muhlenbergerii Engelm.
" *velutina* Lam.
" *stellata* Wang.
" *oblongifolia* Torrey

Urticaceae

Ulmus americana L.
" *racemosa* Thomas
Maclura pomifera (Raf.) Schneider

Nymphaeaceae

Brasenia purpurea Casp.

Anonaceae

Asiminia triloba Dunal.

Platanaceae

Platanus occidentalis L.

ROSACEAE

Crataegus punctata Jacq.
Prunus cf. *pennsylvanica* L.
Prunus species

LEGUMINOSAE

Gleditsia donensis Penhallow
Cercis canadensis L.
Robinia pseudo-acacia L.

ACERACEAE

Acer pleistocenicum Penhallow
" *torontonensis* Penhallow
Acer spicatum Lam.
" *rubrum* L.

SAPINDACEAE

Aesculus glabra Willd.

VITACEAE

Vitis species

TILIACEAE

Tilia americana L.

HALORAGIDACEAE

Hippuris vulgaris L.

ERICACEAE

Clethra alnifolia L.
Vaccinium uliginosum L.

OLEACEAE

Fraxinus americana L.
" *quadrangulata* Michx.
Fraxinus nigra Marsh

CUCURBITACEAE

Echinocystis lobata (Michx.) T. &. G.

ANIMALS

MOLLUSCA

PELECYPODA

UNIONIDAE

Fusconaja undata (Barnes)
" *solida* (Lea)
" *ebena* (Lea)
Crenodonta undulata (Barnes)
Quadrula pustulosa (Lea)
" *pustulosa schoolcraftensis* (Lea)
Pleurobema coccineum (Conrad)
" *pyramidatum* (Lea)
" *clava* (Lam.)
Elliptio gibbosus (Barnes)
Arcidens confragosus (Say)
Anodonta grandis Say
" *grandis footiana* Lea
" *marginata* Say
Ptychobranchus phaseolus (Hildreth)
Nephronajas ligamentina (Lam.)
Eurynia recta (Lam.)
Lampsilis luteola (Lam.)
" *ventricosa* (Barnes)

SPHAERIIDAE

Sphaerium sulcatum (Lamarck)
" *striatinum* (Lam.)
" *stamineum* (Conrad)
Pisidium fallax Sterki
" *punctatum* Sterki
" *compressum* Prime

Sphaerium solidulum (Prime)
" *rhomboideum* (Say)
" *fabale* (Prime)
Pisidium walkeri Sterki
" *cruciatum* Sterki
Pisidium variabile Prime
" *virginicum* (Gmelin)
" *adamsi* Prime
" *noveboracense* Prime
" *abditum* Haldeman

GASTROPODA

Helicinidae

Helicina occulta Say

Pleuroceridae

Pleurocera subulare (Lea)
" *elevatum* (Say)
" *elevatum lewisii* (Lea)
Goniobasis depygis (Say)
" *haldemani* (Tryon)
Anculosa costata Anthony

Viviparidae

Campeloma decisum (Say)
Campeloma subsolidum (Anth.)

Amnicolidae

Amnicola limosa (Say)
" *limosa porata* (Say)
" *emarginata* (Küster)
" *cincinnatiensis* (Lea)
Somatogyrus depressus Tryon
" *isogonus* (Say)
Bythinella tenuipes Couper
Pomatiopsis lapidaria (Say)

Valvatidae

Valvata tricarinata Say
" *sincera* Say
Valvata bicarinata perdepressa Walker

Physidae

Physa heterostropha Say?
" *ancillaria* Say
Aplexa hypnorum (Linne)

Ancylidae

Ancylus tardus Say?
" *rivularis* Say
Ancylus parallelus Hald.

Planorbidae

Planorbis antrosus Conrad
" *trivolvis* Say
" *parvus* Say
Planorbis deflectus Say
" *albus* Müller (=*hirsutus* Gould)
Segmentina armigera (Say)

Lymnaeidae

Lymnaea stagnalis appressa Say
Galba palustris (Müller)
" *reflexa* (Say)
" *elodes* (Say)
Galba obrussa (Say)
" *humilis modicella* (Say)
" *caperata* (Say)

Auriculidae

Carychium exiguum (Say)
Carychium exile H. C. Lea

Valloniidae

Vallonia perspectiva Sterki
" *costata* (Müller)
" *cyclophorella* Ancey
Vallonia gracilicosta Reinh.
" *pulchella* (Müller)

Cochlicopidae

Cochlicopa lubrica (Müller)

Pupillidae

Vertigo tridentata Wolf
" *elatior* Sterki
Pupilla muscorum (Linne)
" *blandi* Morse
Leucochila fallax (Say)
Bifidaria armifera (Say)
" *contracta* (Say)
Bifidaria holzingeri Sterki
" *corticaria* (Say)
" *pentodon* (Say)
Pupoides marginatus (Say)
Strobilops labyrinthica (Say)
" *affinis* Pilsbry

Succineidae

Succinea avara Say
" *retusa* Say
Succinea ovalis Say
" *grosvenori* Lea

Endodontidae

Sphyradium edentulum alticola Ingersoll
Punctum pygmaeum (Draparnaud)
Helicodiscus parallelus (Say)
Pyramidula cronkhitei anthonyi Pilsbry
Pyramidula perspectiva (Say)
" *alternata* (Say)
" *solitaria* (Say)
Oreohelix iowensis (Pilsbry)

Zonitidae

Gastrodonta ligera (Say)
Zonitoides arborea (Say)
" *nitida* (Müller)
Euconulus fulvus (Müller)
Vitrea hammonis (Ström.)
" *indentata* (Say)
" *wheatleyi* (Bland)
Omphalina inornata (Say)

Circinariidae

Circinaria concava (Say)

Helicidae

Polygyra monodon (Rackett)
" *fraterna* (Say)
" *hirsuta* (Say)
" *mitchelliana* (Lea)
" *clausa* (Say)
" *thyroides* (Say)
" *pennsylvanica* (Green)
" *elevata* (Say)
" *palliata* (Say)
Polygyra multilineata (Say)
" *zaleta* (Binney)
" *albolabris* (Say)
" *profunda* (Say)
" *inflecta* (Say)
" *stenotrema* (Fer.)
" *appressa* (Say)
" *tridentata* (Say)

ARTHROPODA

CRUSTACEA

Cypris species
Ostracod, species

INSECTA

Coleoptera

Carabidae

Carabus maeander sangamon Wickham
Elephrus irregularis Scudder
Loricera glacialis Scudder
Pterostichus fractus Scudder
" *destructus* Scudder
" *gelidus* Scudder

Loricera lutosa Scudder
" *exita* Scudder
Nebria abstracta Scudder
Bembidium glaciatum Scudder
" *haywardi* Scudder
" *vestigium* Scudder
" *vanum* Scudder
" *praeteritum* Scudder
" *expletum* Scudder
" *damnosum* Scudder
" *fragmentum* Scudder
Patrobus gelatus Scudder
" *decessus* Scudder
" *frigidus* Scudder
" *henslowi* Wickham
Pterostichus abrogatus Scudder
" *destitutus* Scudder
Pterostichus depletus Scudder
" *dormitans* Scudder
Badister antecursor Scudder
Platynus casus Scudder
" *hindei* Scudder
" *halli* Scudder
" *dissipatus* Scudder
" *desuetus* Scudder
" *harttii* Scudder
" *delapidatus* Scudder
" *exterminatus* Scudder
" *interglacialis* Scudder
" *subgelidus* Wickham
" *interitus* Scudder
" *pleistocenicus* Wickham
" *longavus* Scudder
Chlaenius plicatipennis Wickham
Harpalus conditus, Scudder

DYTISCIDAE

Coelambus derelictus Scudder
" *cribrarius* Scudder
" *infernalis* Scudder
" *disjectus* Scudder
Hydroporus inanimatus Scudder
" *inundatus* Scudder
" *sectus* Scudder
Agabus perditus Scudder
" *savagei* Wickham
" *praelugens* Wickham

GYRINIDAE

Gyrinus confinis LeConte

HYDROPHILIDAE

Cymbiodyta exstincta Scudder
Hydrochus amictus Scudder
Helophorus regescens Scudder

STAPHYLINIDAE

Gymnusa absens Scudder
Quedius deperditus Scudder
Philonthus claudus Scudder
Cryptobium detectum Scudder
" *cinctum* Scudder
Lathrobium interglaciale Scudder
" *antiquatum* Scudder
" *debilitatum* Scudder
" *exesum* Scudder
" *inhibitum* Scudder
Lathrobium frustum Scudder
Oxyporus stiriacus Scudder
Bledius glaciatus Scudder
Geodromicus stiricidii Scudder
Acidota crenata Fabr. (Var. *nigra*)
Arpedium stillicidii Scudder
Olophrum celatum Scudder
" *arcanum* Scudder
" *dejectum* Scudder
" *interglaciale* Wickham

CHRYSOMELIDAE

Donacia stiria Scudder
Donacia pompatica Scudder
" *styrioides* Wickham

CURCULIONIDAE

Erycus consumptus Scudder
Anthonomus eversus Scudder
" *fossilis* Scudder
Anthonomus lapsus Scudder
Orchestes avus Scudder
Centrinus disjunctus Scudder

SCOLYTIDAE

Phloeosinus squalidens Scudder

VERTEBRATA

PISCES

Genus et species incertæ cedis.

REPTILIA

EMYDIDAE

Terrapane carolina (Linn.)

MAMMALIA

MEGATHERIIDAE

Megalonyx jeffersoni (Desmarest)
Mylodon harlani Owen

EQUIDAE

Equus complicatus Leidy
Equus fraternus Leidy

TAPIRIDAE

Tapirus haysii Leidy

TAYASSUIDAE

Platygonus compressus LeConte
" *vetus* Leidy (?)
Tayassu lenis (Leidy) (?)

CERVIDAE

Odocoileus virginianus (Zimm.)
Cervus canadensis Erxlaben
Cervalces scotti Lydekker
Alces americanus Clinton
Rangifer caribou (Gmelin)
Cervalces borealis Bensley

BOVIDAE

Bison latifrons (Harlan)
" *antiquus* Leidy
Symbos cavifrons (Leidy)
Bootherium bombifrons (Harlan)
Ovibos moschatus Zimm.

ELEPHANTIDAE

Mammut americanum Kerr.
Elephas primigenius Blumenbech
" *columbi* Falconer

CASTOROIDIDAE

Castoroides ohioensis Foster

URSIDAE

Ursus procerus Miller

CANIDAE

Urocyon cinereoargentatus Schreber (?)

IV. Summary

Deposits referable to the Sangamon Interglacial interval extend from Iowa thru southern Illinois, Indiana and Ohio to New York. Northward they have been recognized at Toronto, Canada, and near James Bay, as well as in Minnesota, Wisconsin and Michigan. It was an interval, therefore, of wide extent and also, probably, of long duration. The soil horizons and the peat deposits as well as the amount of erosion bear evidences of a long period of exposure to the air. The old forest beds are the most extensive of any interglacial interval, and are widely scattered, being especially well preserved in Iowa, Illinois, Indiana, Ohio, Wisconsin and Ontario.

The climate varied as was the case in the Yarmouth interval, there being evidences (especially at Toronto) of a warm, a temperate and a cold climate. Loess deposits were formed on the Sangamon soils and cover a wide extent of territory along the Mississippi, Illinois, Ohio and other valleys, indicating a period of dry, windy conditions. Land mollusks were abundant, as in the post-Kansan loess.

A large lake was present in the Ontario basin, comparable in size (probably) to the Lake Ontario of today. Coleman thus summarizes the lake conditions in the Ontario region: "Reviewing the old water levels of the Ontario basin . . . , we find that the records commence with the Toronto formation at the middle of an inter-glacial period, and that the succession may be represented in the following table:

(1) Don Stage, warm climate, fresh-water shells, dammed by differential elevation toward the northeast to about 60 feet above present lake. Successor to Laurentian River enters north of Toronto.

(2) Scarboro stage, cold temperate climate, fresh-water shells, deposit conformable with those of last level, but reach 145 feet, and consist of delta materials of Laurentian River.

(3) Low water stage, with subaerial erosion and cutting of river valley to a depth below present lake level.

(4) High water stage, glacial or sub-glacial climate, probably fresh-water shells, ice-dammed to a height of at least 320 feet."

That the other lake basins were also filled with water is rendered certain by analogy, because the naiad fauna at Toronto must have migrated thence from the Mississippi Valley and this could only have been accomplished by way of an interglacial Chicago or Fort Wayne outlet. Evidently there were lakes comparable to the postglacial Chicago, Whittlesey, Warren, Iroquois, etc., long prior to the great waters which have left the evidences of their existence in the old shore lines surrounding the present Great Lakes.

The biota of the Sangamon interval is the most extensive and varied of any of the interglacial intervals, 314 species being known, divided as follows:

	Living	Extinct	Total
Plants	65	3	68
Mollusks	132	1	133
Crustacea	2	0	2
Insects	2	83	85
Vertebrates	6	20	26
Total biota	207	107	314

The plants were abundantly represented, the Pinaceae (8) and Fagaceae (8) leading in the number of species. The large number of deciduous species present is noteworthy. The molluscan fauna was very extensive, embracing nearly all of the families inhabiting the temperate regions. The number of pelecypods is also noteworthy, the two families totalling 35 species. The number of pulmonates (60) is also striking, as is the number of species in the genus *Polygyra* (17). The plants and mollusks are practically the same as those now living in the same region; among the insects, however, all but 2 are extinct. The insects all belong to the order Coleoptera, or beetles, and of these the families Carabidae (41) and Staphylinidae (20) contain the greatest number of species. Of the vertebrates, 20 or about 77 per cent are extinct. Nearly all of these belong to the order Mammalia. As in Yarmouth time the sloth, horse, elephant, mammoth, peccary, bison, musk ox, giant beaver, and many deer roamed the woods and plains. Bear and wolves were also present.

CHAPTER X

THE IOWAN ICE INVASION AND THE PEORIAN INTERGLACIAL INTERVAL

I. The Iowan Ice Invasion

"The Iowan ice invasion is recorded in a thin sheet of till, marked by an exceptional profusion of large granitoid bowlders which lie chiefly on the surface and are somewhat aggregated into a bowlder belt on the eastern border of the tract. The typical Iowan drift was formed by a lobe of the Keewatin ice sheet, occupying the north-central part of Iowa."[1]

The Iowan was once thot to enter the northwestern portion of Illinois[2] but later researches have shown[3] that the till in this region is to be classed as Illinoian. Taylor[4] maps the Iowan as extending southeasterly from beneath the Iowa lobe of the Wisconsin till, well toward, but not reaching the Mississippi River. A small area fringes the Wisconsin till in Wisconsin, north of the driftless area. This is also the area of the Iowan given by the Iowa geologists. Whether there is a lobe from Labrador corresponding to the Iowan beneath the Wisconsin till in Michigan, and farther east, is not definitely known. A till shown in sections near Niagara Falls and at Toronto has been doubtfully referred to this stage. The existence of this drift as a separate till sheet has been questioned by some geologists.

Leverett[5] says of this drift, as found in western Wisconsin overlying Kansan drift: "The so-called Iowan drift may stand in about as close relation to the Illinoian as do the later Wisconsin moraines to the earlier Wisconsin. It does not seem to be separated from the Illinoian drift by a definite interglacial stage but instead to represent a substage or stadium of the Illinoian. It may, therefore, be advisible, pending further study, to apply to it the double name Later Illinoian or Iowan."

The Iowan geologists, however, affirm the existence of the Iowan drift as a distinct till sheet, unrelated to either the Kansan or Illinoian drift sheets. Calvin,[5a] in an analytical paper, summed up the case as follows:

1. The Iowan drift is.
2. The Iowan drift is young compared with the Kansan.

[1] Chamberlin and Salisbury, Geology, III, p. 391.
[2] Leverett, Mon. 38.
[3] Alden, Journ. Geol., XVII, pp. 694-709.
[4] Smith. Rep., 1912, p. 326.
[5] Bull. Geol. Soc. Amer., XXIV, p. 698.
[5a] Bull. Geol. Soc. Amer., XXII, pp. 729-730.

3. The Iowan drift is not a phase of the Kansan.
4. The Iowan drift has certain very intimate relations to certain bodies of loess.
5. The Iowan drift has no close relation to the Illinoian.

Alden[6] affirms the existence of the Iowan drift in northeastern Iowa, coroborating Calvin's opinion, and remarks that "It is older than the Wisconsin and seems to be distinctly younger than the Illinoian" (p. 119). Recently, Alden and Leighton[6a] have made a very careful and extensive study of the Iowan drift, from which "the conclusion has been reached that there is what seems to the writers to be good evidence of the presence of a post-Kansan drift sheet in northeastern Iowa and that this drift appears to be older than the Wisconsin and younger than the Illinoian drift. The writers are, therefore, in the main in agreement with the late State Geologist, Dr. Samuel Calvin, in regard to the Iowan drift. There is, therfore, warrant for continued use of Iowan drift and Iowan stage of glaciation as major subdivisions of the Pleistocene classification" (p. 56).

II. The Peorian Interglacial Interval

The interval between the Iowan and early Wisconsin drifts has been named the Peorian by Leverett,[7] who says: "Extensive deposits of muck and peat at the base of the Wisconsin drift in northern Illinois, notably in McHenry, Kane, Dekalb, LaSalle, and Bureau counties, are in all probability immediately underlain, in some cases at least, by Iowan drift. In central and eastern Illinois the soil is in places underlain by a fossiliferous silt, referred with some confidence to the Iowan loess. In eastern Illinois, as noted above the Iowan till may be present." Leverett's type locality, near Peoria, is unfortunate because the loess here referred to the Iowan is possibly post-Illinoian and therefore equivalent to the Sangamon interval. Some of these deposits may include both the Illinoian and Iowan loesses, and old soils between these loesses may be equivalent to the Peorian interval.

The occurrence of Iowan drift in Illinois has been questioned, the fresh till thot by Leverett and Hershey to be Iowan being ascribed to later erosion. Alden says:[8] "It is quite possible, if not probable, that this till is underlain in part at least by older drift, but that question is not here under discussion. So far as the writer has observed there is no good ground for differentiating the drift exposed at the surface into deposits of more than one stage of glaciation. No intercalated, weathered zones, vegetal or other fossiliferous deposits are known to separate one part of this drift from another. Such as have been

[6] Bull. Geol. Soc. Amer., XXVII, pp. 117-119.
[6a] Ann. Rep. Geol. Survey Iowa, XXVI, pp. 49-212, 1917.
[7] Illinois Glacial Lobe, p. 185.
[8] Alden, Journ. Geol., XVII, p. 696, 1909.

penetrated in wells or otherwise located occur beneath considerable thicknesses of this drift and probably represent an earlier stage of deglaciation."

It seems evident that the drift deposits outside the Wisconsin sheet in Illinois should all be referred to the Illinoian invasion and hence most of the vegetal and other remains below the Wisconsin till should probably be referred to the Sangamon interval and are to be correlated with the old soils overlying the Illinoian drift in central and Southern Illinois. The name Peorian may be retained for soils overlying the Iowan drift in Iowa and for loess overlying the Kansan loess in Iowa and Illinoian loess in Illinois and Indiana.

III. The Iowan Loess

It has been shown by Shimek and other Iowan geologists, that the loess is divisible into several horizons, each horizon representing an interglacial interval.[9] In Iowa, the lower, light bluish or post-Kansan loess is covered by a yellowish loess which is thot to be post-Iowan in age. The yellowish loess is likewise divisible, in certain parts of Iowa, into two deposits, representing the Peorian and Sangamon intervals. These loesses are highly fossiliferous and, according to Shimek, contain about the same species of mollusks. The post-Iowan loess is widely distributed in Iowa. Theoretically there should be three loesses overlying the Kansan drift, viz., 1, the post-Kansan (Yarmouth); 2, the post-Illinoian (Sangamon); and 3, the post-Iowan (Peorian), each with fossils. The post-Kansan in many places probably includes both the Yarmouth and Sangamon intervals, the Illinoian ice not being near enough, apparently, to cause a break in the loess deposits. The same is true of the Sangamon and Peorian loesses outside the influence of the Iowan ice sheet. A typical western section of these deposits is exhibited near Carroll, Carroll County, in the cut along the Chicago Great Western Railway northeast of the city.[10]

6. Wisconsin drift	1–5 feet
5. Yellow loess (post-Iowan?) about	10 feet
4. Interval marking presence of Iowan ice	
4. Bluish gray loess (post-Kansan)	5–6 feet
3. Black, mucky, soil-like band (Yarmouth soil)	1 foot
2. Heavy, reddish joint-clay (Loveland)	1 foot
1. Kansan drift	x feet

Both loesses are fossiliferous but the majority of lists of fossils do not discriminate between the two deposits.

Alden and Leighton,[10a] after a recent exhaustive study of the Iowan loess, reach the following conclusion: "The statement, therefore, seems sound, that the main sheet of loess under consideration was deposited immediately follow-

[9] Shimek, Bull. Lab. Nat. Hist., Univ. Iowa, V, pp. 338-339; 364-368.
[10] Shimek, Iowa Geol. surv., XX, p. 390.
[10a] An. Rep. Iowa Geol. Surv., XXVI, pp. 49-212.

ing the Iowan stage of glaciation. It is therefore a near-correlative of the Iowan drift, though it really represents the early part of the Peorian stage of deglaciation (p. 158).

If studies of the loess deposits covering other drift sheets outside the Wisconsin area should be in complete accord with the results obtained by these authors, the heavy loess deposits of the Mississippi Valley would have a new significance and would indicate, as affirmed by many of the older geologists, a definite period of loess deposition during the Pleistocene. A reexamination of the loess fossil deposits now referred to Yarmouth and Sangamon time would place at least some of these in Peorian time. Until such examinations are made and more extensive study is given the loess overlying the Kansan and Illinoian drift sheets, it has been thot best to leave the biota of these earlier deposits as they were listed before the studies of Alden and Leighton appeared. Many of these lists of loess fossils contain fresh water mollusks (*Planorbis*, *Galba*, *Physa*) and the suggestion is at once presented that possibly these shells came from the lower part of the deposit and represent the ground surface of the Yarmouth or Sangamon interval before the heavy deposit of loess was laid down. The qustion as to whether loess was deposited in any degree during these earlier intervals must also be settled before any satisfactory readjustment of the faunas of the loesses can be made.

IV. The Peorian Biota

1. Iowa

In Harrison and Monona counties this yellow loess is quite fossiliferous and Prof. Shimek has identified a large number of species.[11] A section of the strata in this county, as well as a list of the mollusks noted therein, is shown below:[12]

Section oj loess in Harrison County

Yellow loess (post-Iowan)	6–7 feet
Ferruginous band	4–6 inches
Bluish loess with iron tubules and small calcareous nodules (post-Kansan)	3 feet

List of species in post Iowan loess, Harrison County

Vallonia gracilicosta	*Zonitoides arborea*
Polygyra monodon	" *minuscula*
" *multilineata*	*Pyramidula alternata*
Strobilops labyrinthica	" *cronkhitei anthonyi*
" *virgo*	" *shimekii*
Leucochila fallax?	*Helicodiscus parallelus*
Pupilla muscorum	*Succinea avara*
Bifidaria armijera	" *grosvenori?*

[11] *Op. cit.*, pp. 395–396.

[12] *Op. cit.*, p. 382. The correlations are the author's.

Vertigo modesta
Cochlicopa lubrica
Vitrea hammonis
Euconulus fulvus
Succinea obliqua
Helicina occulta
Eggs of small snails

One of the best eastern loess sections at present known is to be found in and about Iowa City, Johnson County. Both post-Kansan and Post-Iowan loesses occur (the former bluish, the latter yellowish) and both are fossiliferous, the species being the same in both horizons, according to Shimek. The species noted below have been identified from post-Iowan loess:[13]

Galba caperata
" *humilis modicella*
" *obrussa*
Helicina occulta
Succinea avara
" *grosvenori*
" *obliqua* (=*ovalis*)
Vallonia gracilicosta
Bifidaria armifera
" *pentodon*
Vertigo ovata
Pupilla blandi
" *muscorum*
Cochlicopa lubrica
Zonitoides minuscula
Euconulus fulvus
Vitrea indentata
" *hammonis*
Helicodiscus parallelus
Pyramidula cronkhitei anthonyi
" *perspectiva*
" *shimekii*
" *alternata*
Sphyradium edentulum alticola
Oreohelix iowensis
Polygyra profunda
" *multilineata* (small form)

Beyer[14] records loess fossils from two localities in Marshall County, from the upper portions of the deposits, which are probably to be correlated with the post-Iowan loess.

(1). Two miles west of Marshalltown.

Succinea avara
" *obliqua*
Pyramidula shimekii
" *cronkhitei anthonyi*
Euconulus fulvus
Vallonia pulchella (probably *gracilicosta*)
Pupilla muscorum
Bifidaria pentodon
Sphyradium edentulum alticola

(2). One half mile south of Bangor.

Succinea avara
Bifidaria pentodon
Pupilla muscorum
Helicodiscus parallelus

a. *Vertebrate fossils*

Proboscidian remains have been observed in various parts of Iowa in situations possibly referable to the post-Iowan interval. Only a few of the observed records, however, appear definite enough to include in the Peorian interval. Two of these are in Linn County.[15]

[13] Shimek, Amer. Geol., XXVIII, p. 345.
[14] Geol. Iowa, VII, p. 237.
[15] Anderson, Augustana Lib. Pub., V, pp. 28, 29.

(1) Bertram, in a gravel pit.
(2) Springville, in or on Iowan drift.

Dr. Hay[16] cites the following records which may be referable to the Peorian interval.

Black Hawk County. Waterloo, teeth of *Elephas primigenius* in a sand pit, at a depth of 7 feet below the surface. At this depth the deposit would seem to be referable to post-Iowan time (p. 438).

Fayette County. Near Clermont, tooth of *Elephas primigenius* in gravel at depth of 20 feet, at a place between Elgin and Clermont. *Ovibus moschatus* (part of a skull) was found in Township 94, Range 35, in clay at depth of about 26 feet (pp. 81-82; 433-434. Anderson's list, p. 28).

Franklin County. Near Hampton, tooth of *Elephas primigenius* from sand pit near Breed's Lake (Sect. 19, T. 92, R. 20) at a depth of 6 feet (p. 434).

Clayton County. Tooth in Gravel pit two miles east of Garber (sect. 32, T. 92 N, R. 3 W). Possibly Iowan valley train (p. 381).

Dubuque County. One-half mile from Center Grove. Portion of tooth of *Elephas primigenius* found in making drift toward lead crevice. (Hay, p. 433).

It is probable that these animals, as has already been suggested by Dr. Hay, lived in this region when the Wisconsin glacier was not far away. They would, therfore, be correctly placed at the end of the Peorian interval, as their remains appear to be in deposits from the Wisconsin till sheet.

2. NEBRASKA

Many years ago Leidy reported[17] the skull of *Geomys bursarius* from yellow loess deposits near Plattsmouth. Mastodon and elephant teeth were found in the same formation. Hayden[18] refers to the same specimen but indicates that it was in a nodule in the loess. Hayden also reports the buffalo (*Bison*) from marl bluffs near Dakota City, 30 feet below the surface. The exact nature of the deposit is not indicated.

3. MINNESOTA

The Peorian interval is apparently represented in several parts of southeastern Minnesota. On Blue Earth River, near Minnesota River, the following section has been observed:

Deposit		Correlation
1. Ash-colored clay	8 feet 0 inches	Wisconsin.
2. Coarse sand with some pebbles	2 " 0 "	"
3. Ash-colored clay marl	7 " 0 "	"
4. Sand and pebbles, with small boulders at base	8 " 0 "	"

[16] Geol. Iowa Surv., XXIII.
[17] Proc. Phil. Acad., 1867, p. 97.
[18] Final Report, pp. 10-11.

5. Sand with freshwater shells	0 feet 6 inches	Peorian.
6. Sand and gravel	6 " 0 "	Iowan.
7. Sand with fresh water shells	0 " 8 "	Yarmouth
8. Soil and subsoil	6 " 0 "	"
Height of section	38 feet 2 inches	

From number 5 a number of mollusks were obtained, the species being a noted below:[19]

Planorbis parvus	*Campeloma decisum*
" *bicarinatus* (=*antrosus*)	*Goniobasis virginica*[19]
Pseudosuccinea columella	*Unio siliquoides* (=*luteola*)
Physa heterostropha?	*Sphaerium* (=*Cyclas*)

A section at Stillwater, Washington County, may possibly contain a stratum referable to the Peorian interval.

Section[20] *of Strata at Stillwater.*

1. Disturbed sand with some boulders	5 feet
2. Fine sand with nearly horizontal strata	2–6 "
3. Gravel and boulders	0–4 "
4. Very fine sand, horizontal stratification	15 "
5. Coarse gravel and boulders	4–6 "
6. Horizontal strata of fine sand	30–40 "
7. Tripoli bed lies next below this fine sand	

Near the bottom of number 6 the tusk of a mastodon was found.

There are several records which indicate the presence of the remains of life beneath the Wisconsin drift and above the Iowan drift, and hence referable to the Peorian interval. In Carver County[21] a well section shows the succession of strata to be as indicated below:

Till, with many boulders	2–6 feet
Clay, with Unios, 5 feet below surface	20–40 feet
Sand	x feet

The Wisconsin till appears very thin, but can be nothing else.

In Chisago County,[22] at Nessel, a well section exposes the strata noted below:

Soil	2 feet
Yellow till	8 "
Soft blue clay with peaty portions and decaying fragments of wood	4 "
Sand	1+ "
Height of section	15 "

[19] Owen, Rep. Geol. Surv. Wis., Iowa, and Minn., p. 489. *Goniobasis virginica* is an erroneous identification and *Physa heterostropha* is doubtful.

[20] Winchell, Geol. Surv. Minn., Final Rep., II, pp. 397-398.

[21] *Op. cit.*, p. 133.

[22] *Op. cit.*, p. 418.

Other wells vary from 12 to 22 feet, and show similar layers of peaty material.

References to Peorian vertebrates in Minnesota are exceedingly rare. Winchell[23] records *Ovibos* (*Symbos*) *cavifrons* from a farm between Wabasha and Theilman, near the railroad from Wabasha to Zumbrota. It was 10 feet below the surface, in a gravel terrace of the valley. This is in the Driftless Area and it may belong to post-Iowan time. In Winona County, near Stockton, the remains of *Elephas primigenius* were found in Iowan loess.[24]

4. ILLINOIS

Some fossils in the loess of northern Illinois should probably be referred to the Peorian interval. In this horizon should be placed the mollusks from Fulton, Whiteside County, listed by McGee.[25]

Succinea avara	*Vallonia pulchella* (=*gracilicosta*.)
Pyramidula cronkhitei anthonyi	*Pupa* species
Oreohelix iowensis	*Galba humilis modicella*

The upper layers of the loess in other parts of Illinois are doubtless to be classed as post-Iowan (Peorian) but no fossils have been observed.

5. WISCONSIN

The Peorian interval is believed to be represented in Wisconsin but no fossils have been observed. The loess is believed to be post-Iowan and pre-Wisconsin.[26]

6. THE DRIFTLESS AREA

a. *Invertebrate fauna*

The Driftless Area of Wisconsin, Illinois, Iowa, and Minnesota is partly covered with loess deposits, especially along the Mississippi River, a large part of which is referable to the post-Iowan interval. McGee[27] lists eight species from Galena, Illinois, as noted below:

Succinea avara	*Pupilla muscorum*
" *obliqua*	*Bifidaria contracta*
Pyramidula conkhitei anthonyi	*Galba humilis modicella*
Vallonia pulchella	" *obrussa*

[23] N. H. Winchell, Bull. Minn. Acad. Sci., IV, No. 3, p. 419.
[24] *Op. cit.*, p. 416.
[25] Pleistocene History of Northeastern Iowa, p. 448.
[26] Weidman, Science, N. S., XXXVII, p. 457.
[27] *Op. cit.*, p. 448.

Chamberlin and Salisbury[28] list a number of mollusks from the Driftless Area. The species with their localities are tabulated below:

Savanna, Illinois.

Pyramidula cronkheitei anthonyi	*Succinea avara*
Oreohelix iowensis	" *obliqua*

Along some of the tributaries of the Mississippi there are loess-like deposits which are said[28] to be younger than the true loess referred to above. The exact correlation of these deposits seems difficult, but as one locality (Jefferson) affords a characteristic post-Iowan mollusk (*Oreohelix*) they are included here, tho some may be as late as Post-Wisconsin time.

Terraces at Galena, Illinois.

Succinea avara	*Succinea obliqua* (=*ovalis*)
Leucochila fallax	*Planorbis parvus*
Pyramidula cronkhitei anthonyi	*Galba humilis modicella*

20 feet above Apple River, Township 27, JoDaviess County, Illinois.

Pyramidula cronkhitei anthonyi	*Pupilla muscorum*

Higher terraces, Bridgeport, Crawford County, Wisconsin, near mouth of Wisconsin River.

Succinea avara	*Sphyradium edentulum alticola*
" *obliqua*	(=*Vertigo simplex*)
Pyramidula cronkhitei anthonyi	*Galba humilis modicella*

Section 34, Ellenton Township, Grant County, Wisconsin.

Succinea avara

Southwest quarter section 20, Jefferson, Clayton County, Iowa.

Succinea avara	*Pyramidula cronkhitei anthonyi*
" *obliqua*	*Pupilla muscorum*
Oreohelix iowensis	*Sphyradium edentulum alticola* (=*Vertigo*)
Vallonia pulchella	*Galba humilis modicella*

Galena, Illinois, 135 feet above Galena River.

Helicodiscus parallelus	*Succinea avara*
	" *obliqua*

Southwest quarter section 26, Bloomington, Grant County, Wisconsin.

Succinea avara

East of Prairie du Chien, Wisconsin, on the heights at 425 feet above the Mississippi River.

Succinea avara	*Galba humilis modicella*

[28] Driftless Area, pp. 285-286.

Terrace deposits two miles from the mouth of Sinsinawa River and two and a half miles west of Galena, Illinois, contain a fauna of molluscan land shells. This may be the same deposit as that referred to by McGee, Chamberlin, and others. Trowbridge and Shaw[28a] say of this deposit: "So far as our region is concerned the deposition of the loess may have accompanied or followed the Iowan, Illinoian, or even perhaps the Kansan ice epochs, or a part of it may have been deposited during or after each one." It is probable that loess was deposited during each interglacial interval and that these deposits represent an accumulation of all or most of the glacial stages and intervals. As a characteristic Peorian mollusk (*Pyramidula shimekii*) occurs in the deposit the shells recorded may perhaps be considered as having been buried during the Peorian interval.[29] Ten species are recorded, two of which (starred) are figured:

*Pyramidula shimekii**	*Sphyradium edentulum alticola*
Vallonia costata	*Euconulus fulvus*
Pupilla muscorum	*Succinea campestris* (=*grosvenori?*)
Pupilla decora	*Succinea avara**
Bifidaria cf. *corticaria*	*Lymnaea parva*

b. *Vertebrate fauna*

In the southern part of the Driftless Area a vertebrate fauna occurs in the crevices of the limestone, and in the clay immediately overlying the limestone, which seems referable to the Peorian interval, tho some of it may be of later date. In Illinois the crevices are 40 feet beneath the surface. These deposits are near Galena, Illinois, Dubuque, Iowa, and in Grant and Richland counties, Wisconsin. The reason for including the lead region fauna in the Peorian interglacial interval is its geological position, in crevices of the indiginous bed rock covered by clay and loess.

Hay[29a] refers the vertebrates of the driftless area to post-Wisconsin time but the inference is strongly in favor of their being post-Iowan or Peorian, since the region is largely covered with Iowan loess, beneath which many of the bones have been found. There seems no good reason for considering the majority of the finds of later date.

Jeffries Wyman,[30] Joseph Leidy,[31] and John LeConte[32] record the following species, nearly all of which have been found near Galena, Illinois.

[28a] Bull. 26, Ill. Geol. Surv., p. 106.
[29] Galena-Elizabeth Folio, U. S. G. S., No. 200, p. 7.
[29a] Geol. Iowa, XXIII, pp. 38, 487.
[30] Geol. Wis., I, pp. 421-423, 1863.
[31] *Op. cit.*, p. 424.
[32] Amer. Journ. Sci., (iii), V, pp. 103-106.

Wyman	Leidy
Bison bison	*Platygonus compressus*
Odocoileus virginianus	*Procyon priscus*
Mammut americanum	*Anomodon snyderi*
Megalonyx jeffersoni	*Arctomys monax*
Tayassu tajacu? (*lenis*, probably)	*Geomys bursarius*
Canis occidentalis	*Microtus* cf. *pennsylvanicus*
" *latrans*	*Lepus sylvaticus* (=*Sylvilagus floridanus*)
	Canis cinereoargentatus

Leidy[33] repeats this list in his great monograph. J. A. Allen[34] later added two new species from this region and listed some others previously recorded, his list being:

Bison bison	*Antilocapra americana*
Mammut americanum (=*giganteum*)	*Cervus whitneyi* (=*Odocoileus whitneyi*)
Megalonyx	*Canis indianensis*
Platygonus species	" *mississippiensis* (not *dirus*)
Cervus canadensis	

McGee records[35] two species of mammals from JoDaviess County, Illinois, near Dubuque, Iowa, and on an earlier page (135) of the same work lists two additional species.

JoDaviess County

Bison latifrons	*Megalonyx jeffersoni*

Near Dubuque, in crevice in Galena limestone, embedded in clay, 10 feet below the surface.

Megalonyx	*Tayassu tajacu?* (=*T. lenis?*)

Many years ago,[36] Edward Daniels recorded certain animal remains from the driftless area from deposits which are here correlated with the Peorian, tho they may be of later date. *Galba galbana* is recorded from Jamestown and Potosi, Grant County, in great abundance in clay, 20 feet below the surface. The elephant and mastodon are listed from Fairplay and Potosi, and *Elephas* from Sextonville, Richland County.

7. INDIANA

Post-Iowan loess probably caps the post-Illinoian loess in Indiana, particularly along the Wabash and Ohio rivers and some of their tributaries. Few references to this loess, however, have been noted in the literature. Leverett[37] cites the presence of a loess soil and weathered zone in western Johnson County.

[33] Extinct Mammatian Fauna of Dakota and Nebraska, 1869.
[34] Amer. Journ. Sci., (iii), XI, pp. 47-51.
[35] 11th An. Rep., U. S. Geol. Surv., p. 310.
[36] 1st. An. Rep., Geol. Surv. Wis., pp. 10-11, 1854.
[37] Mon. LIII, U.S.G.S., p. 75.

The exposure occurs in Coal Creek, several miles within the Wisconsin drift border. The section is noted below, no fossils being mentioned:

Section of bluff of Coal Creek near corners of secs. 29, 30, and 32, T. 12, R. 3 E.

Till (Wisconsin), yellow at top but shading into blue-gray at bottom	20 feet
Soil, black (Peorian)	1 foot
Silt or clay, pale greenish yellow, pebbleless (post-Sangamon)	3 feet
Till (Illinoian), weathered and leached brown, exposed	5 feet
Height of Section	29 feet

8. MISSOURI

Deposits said to be later than the post-Kansan loess occur along the Missouri River, on the border of the Kansan drift sheet. Mr. F. A. Sampson has collected extensively in these deposits and has obtained the species listed below. At Providence, Boone County, "the deposit is of later period than the Kansan loess, and is not the fine silt of the loess, but is of clay intermixed with stones of various sizes."[38] The species noted from Providence and Lupus are listed below:

Providence, Boone County	Lupus, Moniteau County
Polygyra profunda	*Polygyra profunda*
" *albolabris alleni*	" *albolabris alleni*
" *thyroides*	" *thyroides*
" *elevata*	" *elevata*
' *clausa* (scarce)	" *clausa* (scarce)
" *pennsylvanica*	" *pennsylvanica*
" *appressa*	" *appressa*
" *inflecta*	" *inflecta*
" *fraterna*	" *fraterna*
" *monodon*	" *monodon*
" *hirsuta*	" *hirsuta*
....	*Succinea ovalis* (one specimen)
....	*Gastrodonta ligera* (one specimen)
Helicina occulta (scarce)	*Helicina occulta* (scarce)
....	*Vitrea indentata*
....	" *hammonis?*
....	*Zonitoides minuscula*
....	" *milium*
....	*Bifidaria armifera*
....	" *contracta*
Pyramidula solitaria	*Pyramidula solitaria*
" *alternata*	" *alternata* (rare)
" *perspectiva* (one speciman)	" *perspectiva* (one specimen)
....	*Helidiscus parallelus*
....	*Carychium exile*

[38] Sampson, Nautilus, XXVIII, pp. 15-17.

In his Catalog of Missouri Shells, Sampson adds the following localities which may be referred, with some degree of assurance, to the post-Iowan interval.

Glascow, Howard County.

Helicina occulta	*Polygyra multilineata*
Succinea ovalis	*Pyramidula alternata*
" *avara*	

Kansas City, Jackson County.

Helicina occulta

Booneville, Cooper County.

Helicina occulta

St. Joseph, Buchanan County.

Helicina occulta	*Polygyra divesta*
Bifidaria armifera	" *hirsuta*
Succinea grosvenori	" *monodon*
Pyramidula alternata	

Miss Owen[39] records a number of species from loess deposits in and near St. Joseph. Whether all are referable to post-Iowan loess cannot be known from the text, as no discrimination is made between the loesses. The following species are listed, secured from depths of 12 to 50 feet below the surface.

Helicina occulta	*Patula striatella* (=*Pyramidula cronkheitei anthonyi*
Succinea obliqua	" *alternata* (= " *alternata*)
Polygyra albolabris	

The five species which follow were taken from greater depths.

Circinaria concava	*Succinea luteola*[40]
Polygyra multilineata	" *grosvenori*
	" *avara*

9. KANSAS

The bones of both the elephant and the mastodon have been found in the loess near Manhattan, Riley County, but whether in post-Kansan or post-Iowan loess is not stated.[41] Peorian fossils should be found in that portion of the state covered by the Kansan drift.

[39] Amer. Geol., XXXIII, p. 223.

[40] This is certainly a case of misidentification, *luteola* being a southern species recorded from Texas and Florida.

[41] Mason, Trans. Acad. Sci. St. Louis, VIII, pp. 12-13.

10. CANADA

It has been suggested that the Iowan drift may be represented in Ontario, especially at Toronto (see section, page 328). Near Niagara Falls a boring in the Whirlpool-St. David's channel passed thru strata which might be referable to the Iowan stage (see section, page 323). An old soil underlies 30 feet of sand and gravel in Hamilton (Hunter Street), at the west end of Lake Ontario. This old soil is 2 feet thick[42] and appears in the section as noted below:

Sand and gravel, some cross-bedded	30 feet
Brown clay, unstratified (old soil)..........Peorian?	2 "
Blue till, the upper portion weathered........Iowan?	8 "
Bones of elephant and pieces of wood........Sangamon?	x "

From this layer were collected:

Larix americana
Picea cf. *nigra*
Mammal bone (reported by workman)

The bones of the elephant and the pieces of wood noted at the base of the cutting seem to indicate the presence of the Sangamon interglacial interval. About a mile to the west of the Hunter Street section, in gravel pits, the following section was observed.

Wisconsin.	Clay, making red bricks	6 feet
"	Gravel	30 "
Peorian?	White sand	5 "
Iowan?	Hardpan	4 "
Sangamon?	White sand with mammoth tusks and bones	33 "
	Covered to level of bay	x "
	Height of section	78 feet

Two interglacial intervals are apparently indicated here, the lower is clearly Sangamon while the higher may be Peorian, or it may be a portion of the Wisconsin series. In view of the present attitude of several prominent geologists toward the Iowan there seems need for much additional information before these beds are positively referred to the Peorian interval.

V. Systematic Catalog of the Biota of the Peorian Interglacial Interval

PLANTS

None recorded specifically.

[42] Coleman, Trans. Can. Inst., VI, p. 36; Spencer, Can. Nat., N. S., VII, p. 470; *op. cit.*, X, p. 308.

ANIMALS

MOLLUSCA

PELECYPODA

Unionidae

Lampsilis luteola (Lamarck)

Sphaeriidae

Sphaerium species

GASTROPODA

Helicinidae

Helicina occulta Say

Pleuroceridae

Goniobasis species

Viviparidae

Campeloma decisum (Say)

Physidae

Physa heterostropha Say?

Planorbidae

Planorbis antrosus Conrad
Planorbis parvus Say

Lymnaeidae

Pseudosuccinea columella (Say)
Galba obrussa (Say)
" *galbana* (Say)
Galba humilis modicella (Say)
" *caperata* (Say)
" *parva* (Lea)

Auriculidae

Carycium exile H.C. Lea

Vallonidae

Vallonia gracilicosta Reinh.
Vallonia costata (Müller)
Vallonia pulchella (Müller)

Cochlicopidae

Cochlicopa lubrica (Müller)

Pupillidae

Vertiga modesta Say
" *ovata* Say
" *milium* (Gould)[43]
Pupilla muscorum (Linn.)
" *blandi* (Morse)
" *decora* (Gould)
Leucochila fallax (Say)
Bifidaria armifera (Say)
" *contracta* (Say)
" *pentodon* (Say)
" *procera* (Gould)[43]
" *corticaria* (Say)
Strobilops labyrinthica (Say)
" *virgo* Pilsbry

Succineidae

Succinea avara Say
" *ovalis* Say
Succinea grosvenori Lea

[43] *Vide* Shimek.

ENDODONTIDAE

Sphyradium edentulum alticola (Ingersoll)
Helicodiscus parallelus (Say)
Pyramidula cronkhitei anthonyi Pilsbry
" *perspectiva* (Say)
Pyramidula shimekii (Pilsbry)
" *alternata* (Say)
" *solitaria* (Say)
Oreohelix iowensis (Pilsbry)

ZONITIDAE

Gastrodonta ligera (Say)
Zonitoides arborea (Say)
" *minuscula* (Binney)
" *milium* (Morse)
Euconulus fulvus (Müller)
Vitrea hammonis (Ström)
" *indentata* (Say)

CIRCINARIIDAE

Circinaria concava (Say)

HELICIDAE

Polygyra monodon (Rackett)
" *fraterna* (Say)
" *hirsuta* (Say)
" *clausa* (Say)
" *thyroides* (Say)
" *pennsylvanica* (Green)
" *elevata* (Say)
Polygyra multilineata (Say)
" *albolabris* (Say)
" *albolabris alleni* (Wetherby)
" *profunda* (Say)
" *inflecta* (Say)
" *appressa* (Say)
" *divesta* (Gould)

VERTEBRATA

MAMMALIA

MEGATHERIIDAE

Megalonyx jeffersoni (Desmarest)

TAYASSUIDAE

Tayassu lenis (Leidy)
Platygonus compressus LeConte

CERVIDAE

Odocoileus virginianus (Zimm.)
" *whitneyi* (Allen)
Cervus canadensis Erxlaben

ANTILOCAPRIDAE

Antilocapra americana Ord.

BOVIDAE

Bison bison L.
" *latifrons* (Harlan)
Symbos cavifrons (Leidy)
Ovibos moschatus Zimm.

ELEPHANTIDAE

Mammut americanum (Kerr)
Elephas primigenius Blum.

SCIURIDAE

Marmota monax (Linn.)

MURIDAE

Microtus species (reported as *pennsylvanicus* (Ord.)

GEOMYIDAE

Geomys bursarius (Shaw)

LEPORIDAE

Sylvilagus floridanus (Allen).

LEPTICTIDAE

Anomodon snyderi LeConte

PROCYONIDAE

Procyon priscus LeConte

CANIDAE

Canis mississippiensis Allen
Canis latrans Say
Canis indianensis Leidy
" *occidentalis* Richardson
Urocyon cinereoargentatus (Schreber)

VI. SUMMARY

A difference of opinion prevails among geologists relative to the extent (and even the existence) of the Iowan ice sheet. The exposed portions of this drift sheet are found only in Iowa and a small portion of Minnesota and Wisconsin. The deposits containing evidences of life, however, indicate that there was an interglacial interval following the Kansan and Illinoian, and previous to the Wisconsin, that is easily recognized stratigraphically. Two loesses have been observed in many places, an early and a later. The loesses above the Illinoian till are post-Illinoian (Sangamon) and post-Iowan (Peorian). In Iowa the upper loess is considered post-Iowan, and there should be below this a post-Illinoian overlying a post-Kansan. Deposits referred with confidence to the Peorian interval have been observed in Iowa, Nebraska, Illinois, Minnesota, Wisconsin and Missouri.

Little is known concerning the climate of the Peorian interval, tho it is believed, in Iowa at least, to have been somewhat drier than that of the present time. The flora is very poorly represented (only the presence of wood being recorded) but the fauna is well represented. The biota is tabulated below:

	Living	Extinct	Total
Mollusks	64	2	66
Mammals	10	14	24
Total	74	16	90

Land mollusks predominate as would be expected in loess deposits, 53 species being represented. With few exceptions all are living in Iowan territory at the present time. Of the mammals recorded, 59 per cent are extinct.

SPECIAL CHARACTERISTICS OF LOESS FOSSILS

The fauna of the various loess deposits is but little understood by many geologists, as well as by most zoologists. A paper by Prof. B. Shimek[44] of the

[44] Science, N. S., XXXVII, No. 953, pp. 501-509, 1913.

Iowa State University, ably discusses this subject and some extracts from his paper may fittingly close this chapter.

"In order that the value of these molluscan faunas may be properly meassured it is necessary that they be taken collectively. A single terrestrial shell does not make a land deposit, neither does a single aquatic shell make a water deposit. In water deposits aquatic shells always form a conspicuous part of the fauna, even tho locally they may not predominate. In subaerial deposits aquatic shells may occur, but they are rare and local, and the dominant types are terrestrial. Strictly terrestrial Pleistocene deposits are of two types: buried sand dunes and the loesses. Buried sand dunes are not uncommon in the upper Mississippi Valley, excellent illustrations being found near Gladstone, Illinois; north of Iowa City, Iowa; at Hooper and West Point, Nebraska, and at other points. Neither buried nor surface dunes contain shells so far as observed.

"The loesses are much more satisfactory for our purposes, because they frequently contain fossils and offer by far the best opportunity for the study of Pleistocene terrestrial mollusks. In these deposits terrestrial forms vastly predominate, and fluviatile forms are wholly wanting. So much has been written on this feature of the subject that only reiteration is here possible.

"Fresh-water shells in the loess are very few. They belong to species which inhabit small ponds and boggy places. They are not of the types found in streams and lakes. They are local in distribution, and in a number of cases clearly associated with buried ponds. Ponds are not rare in high places in loess regions. They frequently contain the smaller *Lymnæa*, etc., which are sometimes found in the loess, aquatic birds and insects probably being responsible for their introduction. Such ponds, if buried by subsequent depositions of loess, would present exactly the conditions under which aquatic shells are usually found in the loess. The vastly predominating forms are terrestrial—*upland terrestrial at that*. Some have become extinct in the loess region, but occur westward and southwestward in the drier part of the continent. Such are *Pupa muscorum*, *P. blandi*, *Sphyradium edentulum* var. *alticola*, *Pyramidula shimekii* and *Oreohelix iowensis*. Others like *Succinea grosvenori* and *Vallonia gracillicosta* are still found in the loess region, but they prefer dry, often open grounds. The land species which prefer wet grounds are conspicuously absent from the loess.

"The fossil mollusks do not enable us to determine the age of any of the Pleistocene formations. The fossils of the Aftonian are not sufficiently distinct from those of modern alluvium to permit the drawing of any conclusion other than that the conditions of deposition were much the same. They do not enable us to distinguish between the loesses, for the fossils of the gray and the yellow loesses are, in larger series, essentially the same. But they give us

an excellent measure of the conditions which prevailed at the time of the deposition of the various fossil-bearing Pleistocene strata.

"The terrestrial mollusks which are found in the Pleistocene deposits are also now of very wide distribution and the variation which they exhibit in species, form and size is not at all determined by latitude, but rather by the edaphic conditions under which the forms existed. In both cases the species are those of modern faunas whose habits are well known.

"Variations in the Pleistocene fauna are nowhere better illustrated than in the loess, which has a wide distribution both north and south, and east and west, in the Mississippi Valley. If we begin in the northwestern part of the loess area in Nebraska and western Iowa, we find that the dominant species in the loess are *Pupa muscorum*, *P. blandi*, *Pyramidula shimekii*, *Succinea grosvenori*, *Oreohelix iowensis*, *Vallonia gracilicosta*, *Bifidaria procera*, *Sphyradium edentulum alticola*. These species all belong to a fauna characteristic of the dry western regions, *Pupa muscorum* alone passing by a wide detour northward to the northeastern part of the country. Other species belonging to more easterly faunas appear, as a rule, in smaller numbers. Southward along the Missouri River, as in northwestern Missouri, larger forms, such as *Circinaria concava*, *Pyramidula alternata* and *Polygyra multilineata*, more characteristic of eastern and southeastern faunas, begin to appear in larger numbers. The change southward along the Mississippi is even more striking. In the northerly deposits along the Mississippi *Helicina occulta*, *Pyramidula striatella*, *Succinia ovalis* and *S. avara* are among the most common species. *Pupa decora* is also abundant in both northern and northwestern loess, and while it is largely a boreal species, like *Pupa muscorum*, it extends along the western mountains well into our dry western region.

"Southward along the Mississippi the loess molluscan fauna changes in essentially the same manner as the modern fauna of the surface. At Hickman, Kentucky, the larger helices (so prominent in the southeastern modern fauna) already appear in large numbers and *Pyramidula solitaria*, carinate *Pyramidula alternata*, *Polygyra tridentata*, very large *P. albolabris*, large *P. profunda*, a few *P. elevata*, *P. fraterna*, *P. fraudulenta*, *P. appressa*, *Omphalina fuliginosa*, large *Circinaria concava*, more abundant *Pyramidula perspectiva* and *Gastrodonta ligera*. These species already form the most conspicuous feature of the loess fauna. *Helicina occulta* still appears, though here approaching its southern limit. Still farther south at Dyersburg, Tennessee, a similar fauna appears in the loess, but *Helicina occulta* is not common, reaching here its southern limit and *Pyramidula striatella*, so common in the north, also becomes rare. Still farther south on the west side of the Mississippi River at Helena, Arkansas, the loess fauna becomes still more characteristically southern, and in addition to the larger helices already mentioned the large form of *Succinea ovalis*, *Omphalina kopnodes*, *Vitrea placentula* and *Helicina orbiculata* appear in

conspicuous numbers. The last three species are distinctively southern. *Helicina occulta* has wholly disappeared and its place has been taken by *Helicina orbiculata*. The richly fossiliferous loess of Natchez and Vicksburg, Mississippi, also contains the forms common at Hickman and Helena, and the presence of *Polygyra obstricta*, *P. inflecta* and *P. stenotrema* still further stamps the fauna as distinctively southern.

"But in this variation in the wide loess region there is nothing which suggests a transition or change from cold climate to warm climate faunas or *vice versa*. The variation, as we find it in the loess is practically exactly duplicated in the modern fauna of the surface. The only conclusion, then, which can be drawn from the fossils of the loess is, that during the deposition of the several loesses climatic conditions were not materially different from those which exist in the various parts of the same general region to-day. Such differences as do exist point rather to a drier climate in the northern part of the loess-covered area than that of to-day.

"Emphasis has sometimes been placed upon the depauperation in size of certain loess shells, as evidence that the climate in which they existed was colder than that of to-day. These depauperate shells are found only in the northern part of the loess area, in Iowa, Nebraska, etc. Their exact counterparts are found living to-day in the drier portions of the same region. And corresponding differences do not occur in more easterly series which represent differences in latitude. It is evident that the depauperation is due to drouth and not to a low temperature, and the abundance of these depauperate shells in the northern loess reinforces the evidence already noted that the climate of this region was then somewhat drier than at present."

TABLE OF LOESS FORMATIONS

Prof. Shimek[45] presents the following ideal section as representing the relation of the different loesses to the drift sheets.

Kansan drift
Kansan residual sands and gravels (Buchanan)
Gumbo (Loveland)
Black soil (Yarmouth)
Post-Kansan loess
Illinoian drift
Illinoian residual sands and gravels
Black soil (Sangamon)
Post-Illinoian loess
Iowan drift
Iowan residual sands and gravels

[45] Bull. Lab. Nat. Hist., State Univ., Iowa, V, p. 368.

Black soil (Peorian)
Post-Iowan loess
Wisconsin drift
Wisconsin residual sands and gravels
Post-Wisconsin loess.

These several loesses are quite distinct near the drift borders, but the distinction grows less clear as we recede from the drift margins, especially southward, and finally practically disappears, probably in the regions in which plant-life was not wholly destroyed by the advances of the several ice-sheets succeeding the Kansan.

CHAPTER XI

THE WISCONSIN ICE INVASION

Two till sheets referable to the Wisconsin invasion are recognized, one known as the Earlier Wisconsin and the other as the Late Wisconsin. Of these Chamberlin says:[1]

"*The Earlier Wisconsin glacial stage.*—The formations of the two Wisconsin stages together occupy much larger surface areas than the preceding, because they were not overlapped by later drifts, and they are hence less modified. Besides this, they seem to have had stronger features originally. The till-sheets are marked not only at their borders, but at intervals in the oscillatory recession of the ice, by declared terminal moraines. Kames, eskers, drumlins, and other special forms of aggregation and of outwash mark the surface, and reveal the mode of action of the ice and the glacial waters in a conspicuous way, and are in contrast with the nearly expressionless surface of the older sheets of drift. A part of this difference is due to the greater freshness of the Wisconsin formations; but the larger part, apparently, is assignable to a stronger original expression. This is more markedly true of the later Wisconsin drift than of the earlier. At least three successive terminal morainic tracts characterize that portion of the Early Wisconsin formation in Illinois which was not covered by the Late Wisconsin. The outermost of these lies on the border of the Wisconsin drift, and marks the outermost limit of the ice; the others lie within this outermost belt, and are rudely concentric with it, marking stages of halt, or of minor advance in the general oscillating retreat of the ice.

"*The fifth interval of recession.*—There was an interruption of the retreat of the earlier Wisconsin ice at some unknown line within the area of the later drift, followed by a re-formation of the ice-lobes, and a re-advance of the ice-front. It does not appear that this interval was very long, but it was sufficient to permit the lobes of the ice-sheet to change their relative sizes and their relations to one another to such an extent that the moraines of the later stage at some points cross those of the earlier at large angles. It is uncertain whether the interval should be put in the preceding class, as the shortest representative of a declining series, or referred to a different category, and it has been left unnamed.

"*The Later Wisconsin glacial stage.*—Following this epoch of re-adjustment, the ice margin assumed a pronounced lobate form, and gave rise to the most

[1] Chamberlin and Salisbury, Geology, III, pp. 392-394.

declared moraines, drumlins, and other distinctive glacial formations of the period. The ice radiated not only from the Labradorean, Keewatin, and Cordilleran centers, but from many isolated heights. Nearly all the well-known mountain glaciation of the west is referred to this epoch. The drift-sheet of this stage is characterized by ernormous terminal moraines, by great bowlder belts, by unusual developments of kames, eskers, drumlins, outwash aprons, valley trains, and other diagnostic features of glacial action and glacio-fluvial coöperation. This drift-sheet, far beyond all the others, bears the stamp of the great agency of the period. The disposal of the ice in great lobes is referable to the influence of the great basins. Field studies indicate that broad, smooth-bottomed basins, elongate in the general direction of the ice movement, favored the prolongation of the ice into broad lobes, while sharp, deep valleys of tortuous course or transverse attitude had little effect upon the extension of the ice.

"The Later Wisconsin drift is characterized in some places[2] by nearly a score of concentric moraines which, in some cases, represent re-advances of the ice in the course of its general retreat, and in others perhaps nothing more than halts sufficient to permit an exceptional accumulation of drift at the ice border. There appears to have been exceptional vigor of ice action, correlated with rapidity of melting, resulting in a sharp contest between the antagonistic agencies that made for advance and retreat. The older drift-sheets, so far as overridden by the ice of this epoch, were cut away more largely than in preceding epochs, and the scoring of the rocks below was more prevalent and profound. This was notably so in the great thoroughfares of movement, and for obvious reasons less so where the lateral borders of the lobes only lapped upon the older drift. Extensive overriding of the older drift, without complete removal, occurred in some districts, notably in Illinois and Michigan, as determined by Leverett."

In Ohio there was a period of erosion between the two tills; the cutting of the broad valley of Mad River, two miles in width and 25–50 feet in depth, is referred by Chamberlin to this interval. Other river erosions in this and other parts of the state are also placed in this interval.[3]

LIFE

"As yet no soil, or leached or weathered zones have been found separating the drift of the two series and it seems questionable whether the interval between their deposition was sufficiently long to justify their reference to distinct glacial stages."[4] No life has yet been reported from this interval. However,

[2] Minnesota, Upham, 9th An. Rep. Geol. and Nat. Hist. Surv. of Minn., p. 880; Leverett, Mon. XLI, U. S. Geol. Surv.

[3] Leverett, Monograph XLI, p. 352.

[4] Leverett, Illinois Glacial Lobe, pp. 317-318.

it is possible that many of the marl deposits found on the older Wisconsin till in Illinois, and elsewhere, may be referable to the interval between the deposition of the two drift sheets. The bodies of water in which these marl beds were formed may have been inhabited by hardy mollusks and other animals while the ice front was still in the vicinity of Chicago. An example of this possibility is the marl deposit underlying the campus of the University of Illinois, described on page 127 of this work.

WABASH FAUNA

Hay[5] has proposed the name "Wabash Beds" for the deposits laid down subsequent to the retreat of the late Wisconsin ice sheet, and for the biota he proposes the name "Wabash Fauna," believing that the period between the waning of the ice sheet and the historical period should bear a name and be equivalent in value to the interglacial periods between the different ice sheets. This biota, lying in deposits formed on the surface of the late Wisconsin till sheet, is described in Chapter IV of this volume.

[5] Smith. Mis. Coll., No. 20, p. 13, 1912.

CHAPTER XII

SUMMARY OF THE LIFE OF THE PLEISTOCENE WITHIN THE ENGLACIATED PORTION OF NORTH AMERICA

In the tables at the end of this chapter the biota of the Pleistocene, in that part of North America covered at one time or another by a drift sheet, is arranged to show both systematic and stratigraphic sequence, upward of 685 species of animals and plants being listed. A study of the table below, which is a summary of the large tables at the end of this chapter, brings out some striking features.

Table Showing Number of Living and Extinct Species Recorded from the Glaciated Portion of North America

	Living	Extinct	Total	Percent extinct
Plants	138	7	145	4.8
Animals				
Mollusca	292	6	298	2.
Crustacea	4	0	4	0
Insecta	4	104	108	96.3
Vertebrata	37	93	130	71.5
Totals	475	210	685	30.7

The plants and mollusks are seen to have suffered but little change thruout the Glacial Period, the percentage of extinct species being about 4.8 per cent in plants and 2 per cent in mollusks. Among the insects and vertebrates, however, the case is reversed; of the former, about 96.3 per cent are extinct, and of the latter about 71.5 per cent are extinct. The percentage of extinct mammals varies considerably, decreasing with the advance in time of the Glacial Period. Thus the Port Kennedy cave fauna, herein considered as preglacial, contains 80 per cent of extinct species, while the Conrad Fissure fauna, placed by Hay in the Sangamon interglacial interval,[1] contains 47 per

[1] Dr. Hay places this fauna in the Sangamon (Smith. Mis. Coll., LIX, pages 14-15; Iowa Geol. Surv., XXIII, pages 31-32) but as it is believed to have been destoyed by the influence of the Illinoian ice invasion, its true age must be the interval preceding this invasion, or the Yarmouth (See Science, XXX, page 892, 1909).

cent of extinct species. These groups consist of highly complex organisms which have undergone rapid evolution. The vertical geological range of many of the species and groups is noteworthy; the data are not yet full enough, however, to permit of generalizations, except in a few instances.

I. The Flora

The flora of the Pleistocene differs but little from that of the same area today. At different times during the interglacial intervals the cold temperate plants have been driven southward and their remains have been found to the south of their normal habitat of today. Many species of plants preserved in the Don beds of Torônto (Sangamon interval) as well as in later postglacial deposits, are also found in the Pleistocene of South Carolina, Maryland and Virginia.[2] Likewise, during a period of warmer climate a subtropical and temperate flora flourished at a higher northern latitude than at the present time. As has already been stated, it is probable that each interglacial interval experienced five periods of climatic variation—(1) Arctic, (2) cold temperate, (3) temperate (perhaps subtropical), (4) cold temperate, (5) Arctic. This climatic variation has been observed in only a few places, notably at Toronto and Chicago. The flora of the former locality is the most extensive of any known Pleistocene locality within the glaciated area. The plant remains also attest the presence of swamps, lakes, rivers, and vast forested areas, comparable with the same territory as it was before the advent of the White Man.

Among the plants, trees predominate, perhaps because the woody leaves and stems were more readily preserved. Enough of the other branches of the plant kingdom have been preserved to indicate that they also were abundantly represented.

II. The Fauna.

1. THE MOLLUSCA

Almost half of the life of the Pleistocene belongs to the group of mollusks owing, doubtless, to the hard shelly skeleton which is easily preserved. As in the case of the plants, the most complete molluscan fauna occurs at Toronto and Chicago. A greater or less number of species have also been observed in many other places. The Sangamon interval is the most prolific in the remains of the naiades, evidencing pronounced lake conditions in at least one locality (Toronto). This type of mollusk also flourished during the Aftonian and the Yarmouth intervals. The species from these early deposits show that little change has taken place in this group during the glacial episodes.

The fresh water univalves are abundantly represented in all strata, many species being found in all, or nearly all of the interglacial intervals; notably,

[2] Berry, Journ. Geol., XV, pp. 338-349, 1909.

Valvata tricarinata, *Segmentina armigera*, *Planorbis trivolvis*, *Planorbis antrosus*, *Planorbis parvus*, *Galba caperata*, *Galba humilis modicella*, *Galba obrussa*, and *Galba palustris*.

The land snails are perhaps, the best represented of the mollusks, when all of the interglacial intervals are considered. Many species of some genera persist thruout all of the intervals, as *Vallonia*, *Strobilops*, *Bifidaria* (*Gastrocopta*) *Succinea*, *Helicodiscus*, *Sphyradium*, *Pyramidula*, *Zonitoides*, *Vitrea*, *Euconulus* and *Polygyra*. So far as known these species do not differ materially from the same species as they exist today and it is inferred from this that conditions during at least a part of these intervals did not differ from the conditions of today in the same regions.

It was at one time thot by many biologists that the Glacial Period was a strong factor in the mutation of species and varieties. In 1894 Dr. Pilsbry[3] stated as his opinion that "one of the most potent causes of specific or varietal differentiation has been the glacial epoch which undoubtedly caused a southward movement of the entire northern fauna. Upon the recession of the ice sheet the species thus driven south found themselves exposed to changing climate and food-plants in their new home. Those following the retreat of the ice found the topography, soil and drainage systems of their former area in the north vastly changed." While this factor has been found to have been potent in changing some groups it seems to have had but little effect upon many mollusks, the tables showing that a large number of the species, especially the pulmonates, both land and fresh water, persist practically unchanged from the Aftonian to the present time. The great differentiation of species, especially among the land snails has taken place beyond the limits and inflence of the great ice invasions. Too little is yet known concerning the vertical distribution of the fresh water pulmonates, but the data at hand indicate that but little change has occurred. It is believed by the writer, however, that the great majority of the numerous species of the fresh water pulmonates have been evolved since the retreat of the Wisconsin ice sheet. The species preserved in interglacial deposits show no change from the type of the recent forms of the same species. Further research may carry many of the species into preglacial time and may also add many of the supposed recent species to the list of fossils. As previously explained (Chapter X, page 363) some of the loess fossils attest a change to a drier climate during some of the intervals, a climate similar to that of the southwest in Colorado and adjacent states, and at these times a few peculiar species and races flourished in the loess-covered areas.

II. INSECTA

The insects are peculiar in that all but four species are extinct. The majority of the species are from the Toronto deposits of the Sangamon Interval.

[3] Nautilus, VIII, p. 51.

A less number are from cave deposits thot to be preglacial, while a few are from other interglacial and postglacial deposits. Nearly all of the insects are beetles (Coleoptera) and the majority of the species belong to the families Carabidae and Staphylinidae, the first represented by 51 species and the last by 20 species. Other orders of insects are but meagerly represented, only one, *Phryganea*, being certainly identified. The insect fauna of the Pleistocene will probably be very largely increased in number of species when the interglacial peat deposits are more carefully examined.

III. VERTEBRATA

The vertebrates, like the insects, are notable for the large number of extinct species represented. In this group of animals, whole families are extinct, notably Megatheriidae, Equidae, Camelidae, Elephantidae, and Castoroididae. Among the other families, upwards of half the species are now extinct. The number of species which survived the glacial episodes and became extinct during postglacial (Wabash) time is notable. These are:

Megatherium jeffersoni	*Boötherium sargenti*
Platygonus compressus	*Symbos cavifrons*
Mylohyus nasutus	*Mammut americanum*
Cervalces scotti	*Elephas primigenius*
Cervalces borealis	*Elephas columbi*
Bison latifrons	*Castoroides ohioensis*

Conditions for these animals, as well as for the insects, must have changed radically before the recent or human period. The strong South American element in the vertebrate fauna is to be especially noted—*Megalonyx, Platygonus, Mylohyus*—and also that some of these (as *Platygonus*) extended in postglacial time as far north as New York, Indiana, and Michigan. A northern element is also present in the vertebrate fauna, consisting of the mastodon, northern elephant (mammoth), bison, bear, reindeer, and musk-ox. The horse, so abundant in the Pliocene Period, becomes scarcer and scarcer, and the last authentic records seem to be in the Sangamon interglacial interval. The camels became extinct very early in the Glacial Period. The remains of the Cervidae, Bovidae, Elephantidae, and Canidae occur thruout the different interglacial intervals, indicating that during these intervals a varied mammalian fauna existed.

Cope, Osborn and other paleontogologists have divided the Pleistocene mammals into faunal zones thereby dividing Pleistocene Time into periods corresponding to these faunas. Cope[4] divided the mammals into two faunas, one the Megalonyx fauna, the other the Equus fauna, the former inhabiting the region east of the Great Plains and the latter the western and southwestern

[4] Amer. Nat., XXIV, p. 593.

parts of the country. The two faunas were said by Cope to be contemporary and to have lived during pre-Champlain time. After the Champlain time a new fauna is thought to have appeared, consisting of existing species with a few remnants of the pre-Champlain fauna.

Osborn[5] recognizes four faunas, first, the Equus-Mylodon zone; second, the Megalonyx zone; third, the Ovibos-Rangifer zone; and fourth, the Cervus zone, the latter being the fauna immediately preceding the discovery of America by Columbus. The first two zones are thot by Osborn to be practically contemporary, the Equus-Mylodon zone being, perhaps, a little earlier in appearance. Scott[6] follows Osborn in his treatment of Pleistocene mammals.

These authors in these works have not taken into account the different glacial advances and retreats, and the resulting interglacial intervals, and a true picture of the vertebrate life of the Pleistocene can be gained only by a study of the stratigraphy of the Pleistocene deposits in connection with the biotic remains contained in these deposits, as has already been pointed out by Hay.[7] The deductions of Cope, Osborn and others are mainly based on material found in strata beyond the limits of the ice sheets, which cannot be positively correlated with the glacial divisions of this period for obvious reasons. Many other records are from cave deposits and bed rock fissures, which are usually of doubtful age stratigraphically. Exact knowledge of the extent and survival of Pleistocene mammals (as of other groups of animals and plants) can be gained only by a study of material contained in interglacial deposits of undoubted age. It will probably be possible to separate the Pleistocene mammals into early, middle, and late zones or faunas. Dr. Hay[8] sums up the situation based on our present knowledge in the following words: "It looks, therefore, as if the earliest Pleistocene was characterized by the existence of numerous edentates, horses, camels, tapirs, and saber-tooth cats, and few bisons, while during the later pre-Wisconsin Pleistocene, there were few edentates, few horses, no camels, few saber-tooth cats, but numerous bisons." The tables presented in this chapter furnish evidence of the truth of this statement.

Extended analysis of the tables herein presented would be unwise in the light of our present imperfect knowledge of the life of the different intervals. Factors of stratigraphic differentiation must be found in the insects and mammals, the plants and mollusks being of little value for this purpose on account of their uniformity thruout the interglacial intervals. Plants, however, are good indicators of climatic changes and have had, and will continue to have, an especial value in placing the climate of the fauna which may be found

[5] Age of Mammals, 1910, pp. 452-467; Hay, Smith. Mis. Coll., LIX, pp. 3-15.

[6] A History of Land Animals in the Western Hemisphere.

[7] Smith. Mis. Coll., LIX, pp. 3-16, 1912.

[8] *Op. cit.*, p. 15.

associated with them. Mollusks are excellent indicators of ecological conditions, which they usually rather accurately attest.

III. Man in the Pleistocene

It is singular that the bones of *Homo* have not been found in America in connection with interglacial deposits. There are several references in the literature to such remains in connection with glacial deposits, but investigation has nearly always resulted in referring the specimens to recent burial or inclusion. Some years ago parts of a human skeleton were found in deposits at Lansing, Kansas, thot to be loess of Peorian Age.[9] Later investigations,[10] however, led to the conclusion that the human relics were later in age than the deposits in which they were found, and it was also shown that the deposit was not loess.[11]

In Europe, parts of skeletons, as well as cultural articles, have been found in connection with interglacial deposits. The oldest human remains (described as *Homo heidelbergensis*) were found in deposits referable to the Mindel-Riss interglacial epoch of European glacialogists, which is correlated in time with the Yarmouth or second interglacial interval of American glacialogists.[12] Cultural articles in Europe have also been found in deposits of middle Oligocene age.

Recently, human remains have been reported from deposits in Florida apparently referable to early or middle Pleistocene time. These deposits occur at Vero, on the Atlantic coast of east-central Florida, chiefly in an old stream bed which was uncovered during the construction of a drainage canal. The strata were undisturbed previous to the canal work and it is thot that the human remains, as well as the vertebrate remains associated with them, were deposited in the stream during Pleistocene time.[13] There were associated with the human remains, in addition to the bones of birds, reptiles, amphibians, and fishes, a number of mammal skeletons mostly fragmentary, belonging to the following species:

Didelphis virginiana	*Sigmodon hispidus*
Dasypus species	*Neotoma floridana*
Chlamytherium septentrionalis	*Neofiber alleni*

[9] Upham, Amer. Geol., XXX, pp. 135-150, 1902; Science, N. S., XVI, p. 355; Amer. Geol., XXXII, pp. 185-187, 1903; Williston, Science, N. S., XVI, pp. 195-196, 1902; Amer. Geol., XXXV, pp. 342-346, 1905.

[10] Calvin, Chamberlin, Salisbury, Journ. Geol., X, pp. 745-779, 1902; Shimek, Amer. Geol., XXXII, pp. 362-364, 1904.

[11] Shimek, Bull. Lab. Nat. Hist., Univ. Iowa, V, pp. 346-352, 1904. See also Proc. Iowa Acad. Sci., XXIV, pp. 93-98, 1917.

[12] Osborn, Men of the Old Stone Age; The Age of Mammals.

[13] Sellards, Science, N. S., XLIV, pp. 615-617, 1916; 8th An. Rept. Florida Geol. Surv., pp. 121-160, 1916; 9th An. Rept., Florida Geol. Surv., pp. 69-81, 1917. Also Nelson, Science, N. S., XLVII, pp. 394-395, 1918.

Equus littoralis?
Tapirus haysii?
Tayassu lenis
Bison species
Odocoileus osceola
Odocoileus sellardsiae
Mammut americanum
Elephas columbi
Oryzomys palustris
Sylvilagus palustris
Scalopus aquaticus australis
Ursus floridanus
Procyon lotor
Lutra canadensis
Vulpes palmoria
Canis riviveronis
Canis species
Lynx rufus floridanus

Of the above, 13, or over 50 percent, are extinct, and the conclusion of Dr. Hay as to the age of the deposit seems justified. Commenting on this point, Hay says (*op. cit.*, p. 67): "We are, therefore, confronted by questions as to the antiquity of these human remains. As has already been indicated, the writer believes that the deposits in question are not only of Pleistocene age but of early or middle Pleistocene. He is also convinced, after having examined the locality and collected fossils from it, that the human remains are as old as the deposits in which they are found."

The age of these human remains is not yet entirely clear in the minds of several leading American geologists and anthropologists. A conference was held at Vero in October, 1916, at which the following men were present: Dr. O. P. Hay, Dr. G. G. MacCurdy, Dr. A. Hrdlicka, Dr. T. W. Vaughan, and Dr. R. T. Chamberlain. In March, 1917, Dr. E. W. Berry visited the locality. Papers by these gentlemen relating to the deposits and to the human remains contained therein, have been published in Volume 25 of the Journal of Geology.

The Florida deposits are far beyond the limits of the ice sheets of Pleistocene time and they bear an unknown relation to the interglacial intervals of the Glacial Period. Hay presents some evidence (*op. cit.*, pp. 67, 68) of Man's presence in deposits apparently older than Wisconsin, but while they are suggestive, they are scarcely as definite as desired and necessary for the indubitable evidence of Man's occupancy of the glaciated territory during the progress of the Glacial Period. It remains true, as far as the writer has been able to ascertain, that no undisputed record of the presence of human bones is known from interglacial deposits in the territory once covered by the great ice sheets.

IV. Conclusion

The evidence accumulated during the preparation of this volume indicates that the interglacial intervals, especially the Yarmouth and Sangamon intervals, were of wide extent and long duration and that the animal and plant life was varied and consisted of a large number of species. It is probable that conditions during these intervals were not largely different from those of today, at least during the temperate period of the intervals. Osborn[12] believes that

[14] Hay, 9th An. Rep., Florida Geol. Surv., pp. 43-68, 1917.

the biota was not seriously affected until the Sangamon interval. This author says: "Until toward the close of third Interglacial Times no traces of northern much less arctic forests and animals are discovered anywhere, excepting along the borders of the ice fields. It would appear as if the animal and plant life of Europe and America were, in the main, but slightly affected by the first three glaciations. We cannot entertain for a moment the belief that in glacial times all the warm fauna and flora migrated southward and then returned, because there is not a shred of evidence for this theory. It is far more in accord with the known facts to believe that all southern and eastern forms of life had become very hardy, for we know how readily animals now living in warm earth belts are acclimatized to northern conditions."

It is probable that Osborn here has in mind the biota living at the margin or somewhat to the south of the ice front, because all the evidence indicates that all life moved southward in the path of the advancing glacier or suffered extinction. There was undoubtedly an unusual commingling of arctic, temperate, and warm faunas and floras in the region south of the ice sheet and the southern forms probably did become more or less acclimatized to a climate colder than was normal for them; but when the ice sheet melted and retreated the arctic and temperate animals undoubtedly migrated northward, as is plainly indicated by the remains of these animals and plants in territory to the north of the southern boundary of the till sheets (cf. Aftonian and Yarmouth).

Salisbury[15] sums up the effect of the Ice Age on the biota and his conclusions seem to well describe the situation as it is indicated by the facts at present known.

"The great changes in the physical processes which this on-coming of the ice-sheets brought into operation, effected corresponding changes in life and in the processes which depend on life. In the first place, the total amount of land life must have been greatly reduced. If account be taken of mountain glaciation in both hemispheres as well as of the ice-sheets, it is probably within the limits of truth to say that conditions became so far inhospitable as nearly to eliminate land life from about one-seventh of the land of the globe, and to have rendered conditions relatively inhospitable over a still larger area. . .

"The crowding of land life off 8,000,000 square miles, more or less, must have tended to concentrate it upon the land which still remained hospitable, and to decimate or exterminate those forms which could not migrate readily. . . . It would seem, from the series of physical changes sketched, that very profound changes in life should have followed, but it must be confessed that,

[15] Outlines of Geologic History with especial Reference to North America, pp. 271-272. References to marine conditions are omitted.

in spite of the conditions which it would seem must have been favorable for great destruction of life, and for imposing great modifications upon that which survived, statistical evidences of the changes which followed are less impressive than would have been expected. The data at hand point to extensive migrations, but not to exterminations and profound modifications which might have been expected. It seems impossible to think that the changes of climate which drove musk oxen to Kentucky and Virginia, and Arctic plants and reindeer to the lowlands of central Europe and to the Mediterranean, were without very profound biologic significance, unless the life of the earth had reached a condition of far greater stability than that of earlier times, when lesser physical changes seem to have produced greater biological changes."

Table showing Distribution of Life during each Interglacial Interval

Interglacial Interval	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Total
Plants	7	23	12	14	68	0	66	145
Animals								
Mollusca	6	4	50	91	132	66	244	298
Crustacea	0	1	0	0	2	0	2	4
Insecta	104	14	0	0	85	0	9	108
Pisces	0	0	0	1	0	0	2	3
Amphibia	0	1	0	0	0	0	0	1
Reptilia	4	4	1	0	1	0	0	6
Aves	2	2	0	0	0	0	1	3
Mammalia	87	79	24	18	25	24	21	117
Total Animals	203	105	75	110	245	90	279	540
Total Life	210	128	87	124	313	90	345	685

It is apparently in accord with the ascertained facts, as indicated by the fossil remains found between the till sheets, and listed in this work, to believe that at each interglacial interval there was first a migration northward into territory laid bare by the retreating ice and later a southward migration as the climate changed with the on-coming of the new glaciaton; that this to and fro migration was repeated four times and is now in its fifth northward migration period; and that the effect of such forced migrations has been to cause the extinction of many species of insects and mammals, while causing little change in plants and mollusks. There were probably other causes contributary to the extinction of the insects and mammals, but we must believe, from the stratigraphical evidence, that the physical changes brought on by the Glacial Period contributed largely to the dying out of so many species of these two highly

developed groups which were evidently not as able to adapt themselves to changing conditions as were the other groups. Additional data may change these deductions, which, however, seem to be justified by the information provided by the animal life thus far obtained from deposits laid down between the several till sheets.

V. Systematic List of Species

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
PLANTS								
BYROPHYTA								
SPHAGNACEÆ								
Sphagnum species		x		x				x
FONTINALACEAE								
Fontinalis species					x			x
Dichelyma capillaceum (L.) Schimp					x			x
HYPNACEAE								
Camptothecium nitens (Schreb.) Schimp			x					x
Drepanocladus fluitans (L.) Warnst			x				x	x
" *revolvens* Swartz			x					x
" *aduncus* (L.) Warnst				x				x
" *intermedius* (Lindb.) Warnst					x			x
Calliergon richardsoni Lesq. and James			x					x
Sematophyllum recurvans (Michx.) Britton					x			x
Hypnum(?) *commutatum* Hedw					x			x
Plagiothecum denticulatum roseanum (Hempe) B. & S.							x	x
CHARACEAE								
Chara species					x		x	x
PTERIDOPHYTA								
EQUISETACEAE								
Equisetum sylvaticum L.							x	x
" *fluviatile* L.							x	x
" *scirpoides* Michx							x	x
" species					x			
LYCOPODIACEAE								
Lycopodium selago L.							x	x
" species					x			

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
SPERMATOPHYTA								
GYMNOSPERMAE								
TAXACEAE								
Taxus canadensis Marsh					x			x
" *minor* (Michx.) Britton					x			x
PINACEAE								
Pinus rigida Mill		x		x			x	x
" *strobus* L					x			x
" *taeda* L							x	x
" species		x						
Larix laricina (DuRoi) Koch					x		x	x
" *churchbridgensis* Penhallow	x							
Picea mariana (Mill.) BSP			x		x		x	x
" *canadensis* (Mill.) BSP				x	x		x	x
" species			x	x				
Abies balsamea (L.) Mill					x		x	x
Thuja occidentalis L					x		x	x
Juniperus virginiana L				x	x		x	x
Chamaecyparis thyoides (L.) BSP					x			x
Taxodium distichum (L.) Richard							x	x
ANGIOSPERMAE								
MONOCOTYLEDONAE								
TYPHACEAE								
Typha latifolia L							x	x
NAJADACEAE								
Potamogeton natans L							x	x
" *perfoliatus* L							x	x
" *pusillus* L							x	x
" *rutilus* Wolfgang							x	x
" *pectinatus* L							x	x
" species					x			
Najas species							x	
HYDROCHARITACEAE								
Elodea canadensis Michx				x			x	x
Vallisneria spiralis L				x			x	x
GRAMINEAE								
Species indet			x	x				
Festuca ovina L					x			x
Oryzopsis asperifolia Michx							x	x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Cyperaceae								
Carex paupercula irrigua (Wahl.) Fernald							x	x
" *aequatilis* Wahlenb.					x			x
" *reticulata*					x			x
" species				x			x	
Scirpus fluviatilis (Torr.) Gray					x			x
Scirpus species							x	x
Eriocaulaceae								
Eriocaulon species					x			
Dicotyledoneae								
Salicaceae								
Salix uva-ursi Pursh							x	x
" species					x			
Populus grandidentata Michx.					x		x	x
" *balsamifera* L.					x		x	x
" species			x					
Juglandaceae								
Juglans cinera L.							x	x.
" species		x	x					
Carya cordiformis (Wang.) Koch							x	x
" *glabra* (Mill.) Spach		x					?	x
" *alba* (L.) Koch		x			x			x
Betulaceae								
Corylus americana Walt.		x						x
Betula species		x						
" *alba* L.					x		x	x
" *lutea* Michx.							x	x
Alnus species					x		x	
Ostrya virginiana (Mill.) Koch					x			x
Fagaceae								
Fagus grandifolia Ehrb.		x			x		x	x
Quercus alba L.		x			x		x	x
" *macrocarpa* Michx.		x			x			x
" *palustris* Meunch.		x						x
" *muhlenbergerii* Englhm.					x			x
" *vellutina* Lam.					x			x
" *stellata* Wang.					x			x
" *marcyana* Penhallow	x						x	
" *phellos* L.							x	x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Quercus rubra L.					x			x
" *rubra ambigua* (Michx.) Fernald							x	x
" *oblongifolia* Torrey					x			
URTICACEAE								
Ulmus americana L.					x			x
" *racemosa* Thomas					x			x
" species			x					
Maclura pomifera (Raf.) Schneider					x			x
POLYGONACEAE								
Polygonum species					x			
Oxyria digyna (L.) Hill							x	x
CHENOPODIACEAE								
Chenopodium species					x			
CERATOPHYLLACEAE								
Ceratophyllum demersum L.					x			x
NYMPHAEACEAE								
Nymphaea advena Ait.							x	x
Brasenia schreberi Gmelin							x	x
" *purpurea* (Michx.) Casp.					x			x
RANUNCULACEAE								
Ranunculus aquatilis capillaceus DC.							x	x
MAGNOLIACEAE								
Magnolia species		x						
Liriodendron tulipifera L.		x						x
ANONACEAE								
Asiminia triloba Dunal					x			x
DROSERACEAE								
Drosera rotundifolia L.							x	x
HAMAMELIDACEAE								
Liquidambar straciflua L.		x						x
PLATANACEAE								
Platanus occidentalis L.		x			x		x	x
ROSACEAE								
Crataegus species		x						
" *crusgalli* L.		x						x
" *punctata* Jacq.					x			x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Prunus virginiana L.							x	x
" cf. *pennsylvanica* L.					x			x
" species		x			x			
Potentilla monspeliensis norvegica (L.) Rydb.							x	x
" *tridentata* Ait.							x	x
" *anserina* L.							x	x
" *canadensis* L.							x	x
LEGUMINOSAE								
Trifolium repens L.							x	x
Gleditsia donensis Penhallow	x				x			
Cercis canadensis L.					x			x
Robinia pseudo-acacia L.					x			x
ACERACEAE								
Acer pleistocenicum Penhallow	x				x			
" *torontonensis* Penhallow	x				x			
" *spicatum* Lam.					x		x	x
" *rubrum* L.					x			x
" *saccharinum* L.							x	x
" species		x						
SAPINDACEAE								
Aesculus glabra Willd.					x			x
VITACEAE								
Psedera quinquefolia (L.) Greene		x						x
Vitis species			x		x			
" *aestivalis* Michx.							x	x
" *pseudorotundifolia* Berry	x						x	
RHAMNACEAE								
Zizyhus species							x	
TILIACEAE								
Tilia dubia (Newberry)	x	x						
" *americana* L.					x			x
VIOLACEAE								
Viola palustris L.							x	x
HALORAGIDACEAE								
Hippuris vulgaris L.					x			x
CORNACEAE								
Nyssa sylvatica biflora (Walt.) Sarg.		x						x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
ERICACEAE								
Clethra alnifolia L.					x			x
Vaccinium uliginosum L.					x		x	x
" *oxycoccus* L.							x	x
Rhododendron lapponicum (L.) Wahlenb.							x	x
Arctostaphylos alpina (L.) Spreng.							x	x
" *uva-ursi* (L.) Spreng.							x	x
Gaylussacia baccata (Wang.) Koch.							x	x
OLEACEAE								
Fraxinus americana L.					x			x
" *quadrangulata* Michx.					x			x
" *nigra* Marsh.					x			x
GENTIANACEAE								
Menyanthes trifoliata L.							x	x
BORAGINACEAE								
Lithospermum species				x				
CUCURBITACEAE								
Echinocystis lobata (Michx.) T. and G.					x			x
ANIMALS								
MOLLUSCA								
PELECYPODA								
UNIONIDAE								
Fusconaja undata (Barnes)					x		x	x
" *solida* (Lea)					x		x	x
" *ebena* (Lea)					x			x
" *chunii* (Lea)				x				x
" *rubiginosa* (Lea)				x				x
Crenodonta peruviana (Lamarck)							x	x
" *undulata* (Barnes)				x	x		x	x
" *perplicata* (Conrad)				?				x
Quadrula asper (Lea)				x				x
" *pustulosa* (Lea)				x	x		x	x
" *pustulosa schoolcraftensis* (Lea)					x		x	x
" *metanevra* (Rafinesque)			x				x	x
" *lachrymosa* (Lea)							x	x
Rotundaria tuberculata (Rafinesque)							x	x
Plethobasus aesopus (Green)							x	x
Pleurobema coccineum (Conrad)					x		x	x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Pleurobema coccineum magnalacustris (Simpson)							x	x
" *obliquum* (Lam.)				x				x
" *pyramidatum* (Lea)					x			x
" *clava* (Lam.)					x			x
Elliptio crassidens (Lam.)							x	x
" *gibbosus* (Barnes)					x		x	x
" *complanatus* (Dillwyn)							x	x
Arcidens confragosus (Say)					x			x
Lasmigona costata (Rafinesque)							x	x
" *compressa* (Raf.)							x	x
Anodonta grandis Say					x		x	x
" *grandis footiana* Lea					x		x	x
" *marginata* Say					x		x	x
" *cataracta* Say							x	x
" *imbecilis* Say			x					x
Anodontoides subcylindraceus (Lea)							x	x
Alasmidonta marginata (Say)							x	x
" *calceola* (Lea)							x	x
Ptychobranchus phaseolus (Hildreth)					x			x
Obovaria circula (Lea)							x	x
" *ellipsis* (Lea)							x	x
Obliquaria reflexa Rafinesque							x	x
Amygdalonajas elegans (Lea)							x	x
Nephronajas ligamentina (Lam.)					x		x	x
Proptera alata (Say)							x	x
" *purpurata* (Lam.)				x				x
Eurynia iris (Lea)							x	x
" *ellipsiformis* (Conrad)							x	x
" *recta* (Lam.)					x		x	x
Lampsilis anodontoides (Lea)			x				x	x
" *luteola* (Lam.)					x	x	x	x
" *ventricosa* (Barnes)					x		x	x
SPHAERIIDAE								
Sphaerium sulcatum (Lam.)		x	x	x	x		x	x
" *striatinum* (Lam.)		x	x	x	x		x	x
" *solidulum* (Prime)					x		x	x
" *stamineum* (Conrad)					x		x	x
" *stamineum wisconsinensis* Sterki							x	x
" *rhomboideum* (Say)					x		x	x
" *fabale* (Prime)					x			x
" *occidentale* (Prime)							x	x
" *flavum* (Prime)							x	x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Sphaerium emarginatum (Prime)							x	x
" *acuminatum* (Prime)							x	x
" *torsum* Sterki							x	x
" *levissimum* Sterki							x	x
" species						x		
Musculium secure (Prime)							x	x
" *transversum* (Say)				x			x	x
" *truncatum* (Linsley)							x	x
" *partumeium* (Say)							x	x
" *rosaceum* (Prime)							x	x
Pisidium abditum (Haldeman)		x	x	x	x		x	x
" *adamsi* (Prime)					x		x	x
" *adamsi affine* Sterki							x	x
" *compressum* (Prime)			x	x	x		x	x
" *compressum confertum* Sterki							x	x
" *compressum laevigatum* Sterki							x	x
" *compressum illinoisense* Sterki							x	
" *contortum* (Prime)							x	x
" *costatum* Sterki	x						x	
" *cruciatum* Sterki					x			x
" *fallax* Sterki					x		x	x
" *idahoense* Roper							x	x
" *kirklandi* Sterki							x	x
" *mainense* Sterki							x	x
" *medianum* Sterki				x			x	x
" *medianum minutum* Sterki							x	x
" *milium* (Haldeman)							x	x
" *noveboracense* (Prime)					x		x	x
" *ohioense* Sterki							x	x
" *pauperculum* Sterki							x	x
" *punctatum* Sterki					x			x
" *roperi* Sterki							x	x
" *rotundatum* Prime							x	x
" *sargenti* Sterki							x	x
" *scutellatum* Sterki							x	x
" *splendidulum* Sterki							x	x
" *superius* Sterki							x	x
" *tenuissimum* Sterki							x	x
" *tenuissimum calcareum* Sterki							x	
" *trapezoideum* Sterki							x	x
" *triangulare* Sterki							x	x
" *ultra-montanum* (Prime)							x	x
" *variabile* (Prime)				x	x		x	x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Pisidium ventricosum (Prime)							x	x
" *ventricosum costatum* Sterki							x	x
" *vesiculare* Sterki?							x	x
" *virginicum* (Gmelin)					x		x	x
" *walkeri* Sterki					x		x	x
" *politum* Sterki							x	x
" *politum decorum* Sterki							x	x
GASTROPODA								
HELICINIDAE								
Helicina occulta Say			x	x	x	x	x	x
PLEUROCERIDAE								
Pleurocera subulare (Lea)					x		x	x
" *elevatum* (Say)					x		x	x
" *elevatum lewisii* (Lea)					x			x
" *canaliculatum* (Say)				x				x
" *alavere* (Conrad)				x				x
" *unciale* (Haldeman)				x				x
" species				x				
Goniobasis livescens (Menke)							x	x
" *livescens niagarensis* (Lea)							x	x
" *haldemani* Tryon					x		x	x
" *depygis* (Say)					x		x	x
" species						x		
Anculosa costata Anthony					x			x
AMNICOLIDAE								
Pyrgulopsis scalariformis Wolf							x	x
Pomatiopsis lapidaria (Say)				x	x		x	x
Amnicola limosa (Say)					x		x	x
" *limosa porata* (Say)				x	x		x	x
" *limosa parva* (Lea)							x	x
" *emarginata* (Küster)			x		x		x	x
" *cincinnatiensis* (Lea)					x		x	x
" *lustrica* Pilsbry							x	x
" *letsoni* Walker							x	x
" *galbana* (Say)	x						x	
" *walkeri* Pilsbry							x	x
" species			x					
Somatogyrus integer (Say)							x	x
" *subglobosus* (Say)					x		x	x
" *depressus* Tryon					x			x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Paludestrina nickliniana (Lea)							x	x
Bythinella tenuipes Couper					x			x
VIVIPARIDAE								
Vivipara intertexta (Say)							x	x
" *subpurpurea* Say							x	x
Campeloma decisum (Say)					x	x	x	x
" *ponderosum* (Say)				x				x
" *subsolidum* (Anthony)				x	x		x	x
" *subsolidum exilis* (Anthony)							x	x
" *integrum* (DeKay)							x	x
" *integrum obesum* (Lewis)							x	x
Lioplax cyclostomatiformis (Lea)				x				x
VALVATIDAE								
Valvata sincera (Say)				?	x		x	x
" *lewisii* Currier				x			?	x
" *obtusa* Drap							x	x
" *tricarinata* (Say)		x	x	x	x		x	x
" *tricarinata confusa* Walker							x	x
" *tricarinata simplex* Gould							x	x
" *tricarinata unicarinata* DeKay							x	x
" *tricarinata infracarinata* Vanatta							x	x
" *bicarinata* (Lea)			x				x	x
" *bicarinata perdepressa* Walker					x		x	x
PULMONATA								
PHYSIDAE								
Physa heterostropha Say					?	?	x	x
" *sayii* Tappan			?				x	x
" *ancillaria* Say					x		x	x
" *warreniana* Lea							x	x
" *integra* Haldeman			x				x	x
" *niagarensis* Lea							x	x
" *walkeri* Crandall							x	x
" *gyrina* Say			x	x			x	x
" *gyrina hildrethiana* Lea							x	x
" *elliptica* Lea							x	x
" *aplectoides* Sterki							x	x
Aplexa hypnorum (Linn.)			x		x		x	x
ANCYLIDAE								
Gundlachia species							x	x
Ancylus parallelus Haldeman					x		x	x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Ancylus rivularis Say			x		x		x	x
" *fuscus* Adams							x	x
" *tardus* Say					?			x
" *kirklandi* Walker							x	x
PLANORBIDAE								
Segmentina armigera (Say)			x		x		x	x
Planorbis trivolvis Say				x	x		x	x
" *binneyi* Tryon							x	x
" *campanulatus* Say							x	x
" *antrosus* Conrad			x	x	x	x	x	x
" *antrosus striatus* Baker				x			x	x
" *antrosus angistomus* Haldeman							x	x
" *altissimus* Baker							x	
" *exacuous* Say				x			x	x
" *rubellus* Sterki							x	x
" *deflectus* Say				x	x		x	x
" *umbilicatellus* Cockerell							x	x
" *hirsutus* Gould			x		x		x	x
" *dilatatus* Gould			x					x
" *parvus* Say			x	x	x	x	x	x
" *parvus urbanensis* Baker							x	
" *crista* Linn ?							?	x
" *crista cristata* Drap							x	x
LYMNAEIDAE								
Lymnaea stagnalis appressa (Say)					x		x	x
Pseudosuccinea columella (Say)				x		x	x	x
Acella haldemani (Desh. Binn.)							x	x
Galba caperata (Say)			x	x	x	x	x	x
" *parva* (Lea)						x	x	x
" *dalli* (Baker)							x	x
" *humilis modicella* (Say)			x	x x	x	x	x	x
" *humilis rustica* (Lea)							x	x
" *obrussa* (Say)			x	x	x	x	x	x
" *obrussa decampi* (Streng)							x	x
" *obrussa exiqua* (Lea)							x	x
" *galbana* (Say)			x			x	x	x
" *anticostiana* (Dall)	x						x	
" *bakeri* (Walker)	x						x	
" *palustris* (Müller)			x	x	x		x	x
" *reflexa* (Say)			x		x		x	x
" *elodes* (Say)					x			x
" *nashotahensis* (Baker)	x						x	

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Galba catascopium (Say)				x			x	x
" *emarginata canadensis* (Sowb.)							x	x
AURICULIDAE								
Carychium exiguum (Say)			x	x	x		x	x
" *exile* H. C. Lea			x	x	x	x	x	x
VALLONIIDAE								
Vallonia parvula Sterki				x			x	x
" *gracilicosta* Reinh.			x	x	x	x	x	x
" *costata* (Müller)			x		x	x		x
" *pulchella* (Müller)				x	x	x	x	x
" *perspectiva* Sterki					x			x
" *cyclophorella* Ancey					x			x
PUPILLIDAE								
Strobilops labyrinthica (Say)			x	x	x	x	x	x
" *affinis* Pilsbry					x		x	x
" *virgo* Pilsbry			x	x		x		x
Pupoides marginatus (Say)					x		x	x
[16]*Bifidaria armifera* (Say)			x	x	x	x	x	x
" *contracta* (Say)			x	x	x	x	x	x
" *pentodon* (Say)				x	x	x	x	x
" *tappaniana* (C. B. Adams)				x			x	x
" *holzingeri* Sterki				x	x			x
" *procera* (Gould)				x		x		x
" *corticaria* (Say)					x	x	x	x
Pupilla muscorum (Linn.)				x	x	x		x
" *blandi* (Morse)				x	x	x		x
" *decora* (Gould)						x		x
Leucochila fallax (Say)				x	x	x		x
Vertigo tridentata Wolf					x		x	x
" *ovata* Say				x		x	x	x
" *milium* Morse				x		x	x	x
" *morsei* Sterki							x	x
" *bollesiana* Morse				x				x
" *elatior* Sterki					x		x	x
" *modesta* Say						x		x
COCHLICOPIDAE								
Cochlicopa lubrica (Müller)				x	x	x		x
SUCCINEIDAE								
Succinea ovalis Say			x	x	x	x	x	x
" *avara* Say			x	x	x	x	x	x

[16] This genus is now known as Gastrocopta

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Succinea grosvenori Lea				x	x	x		x
" *retusa* Lea			x	x	x		x	x
ENDODONTIDAE								
Sphyradium edentulum alticola Ingersoll			x	x	x	x	x	x
Helicodiscus parallelus (Say)			x	x	x	x	x	x
Punctum pygmaeum (Drap.)					x		x	x
Pyramidula cronkhitei anthonyi Pilsbry			x	x	x	x	x	x
" *perspectiva* (Say)				x	x	x	x	x
" *shimekii* (Pilsbry)				x		x		x
" *alternata* (Say)			x	x	x	x	x	x
" *solitaria* (Say)				x	x	x	x	x
Oreohelix iowensis (Pilsbry)	x			x	x	x		
LIMACIDAE								
Agriolimax campestris Binney							x	x
Limacid, species indet							x	x
ZONITIDAE								
Gastrodonta ligera (Say)				x	x	x	x	x
Zonitoides arborea (Say)			x	x	x	x	x	x
" *nitida* (Müller)					x			x
" *minuscula* (Binney)			x	x		x	x	x
" *laeviscula* Sterki							x	x
" *milium* (Morse)						x		x
Euconulus fulvus (Müller)			x	x	x	x	x	x
" *chersinus* (Say)							x	x
" *chersinus polygyratus* (Pilsbry)							x	x
" *sterkii* (Dall)							x	x
Vitrea hammonis (Ström)			x	x	x	x	x	x
" *indentata* (Say)				x	x	x	x	x
" *rhoadsi* Pilsbry							x	x
" *wheatleyi* (Bland)					x		x	x
Omphalina fuliginosa (Griffith)							x	x
" *inornata* (Say)					x			x
CIRCINARIIDAE								
Circinaria concava (Say)					x	x	x	x
HELICIDAE								
Polygyra monodon (Rackett)			x	x	x	x	x	x
" *fraterna* (Say)				x	x	x	x	x
" *hirsuta* (Say)				x	x	x	x	x
" *mitchelliana* (Lea)					x		x	x
" *clausa* (Say)				x	x	x	x	x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Polygyra thyroides (Say)				x	x	x	x	x
" *pennsylvanica* (Green)					x	x	x	x
" *elevata* (Say)				x	x	x	x	x
" *palliata* (Say)					x		x	x
" *multilineata* (Say)			x	x	x	x	x	x
" *zaleta* (Binney)				x	x		x	x
" *albolabris* (Say)				x	x	x	x	x
" *albolabris alleni* (Wetherby)						x		x
" *albolabris dentata* (Tryon)							x	x
" *sayana* Pilsbry							x	x
" *profunda* (Say)			x	x	x	x	x	x
" *inflecta* (Say)				x	x	x	x	x
" *stenotrema* (Fer.)					x			x
" *appressa* (Say)				x	x	x		x
" *tridentata* (Say)					x		x	x
" *fraudulenta* Pilsbry							x	x
" *divesta* (Gould)						x		x
ARTHROPODA								
CRUSTACEA								
Cambarus blandingi acutus Girard							x	x
Gammarus species		x						
Cypris					x		x	
Ostracod					x			
INSECTA								
COLEOPTERA								
Wings of beetles			x	x				
BYRRHIDAE								
Byrrhus ottawaensis Scudder	x						x	
SCARABAEIDAE								
Aphodius praecursor Scudder	x	x						
" *nucans* Scudder	x	x						
" *scutellaris* Scudder	x	x						
Phanaeus antiquus Scudder	x	x						
Choeridium ebeninum Scudder	x	x						
CARABIDAE								
Chlaenius punctatissimus Scudder	x	x						
" *plicatipennis* Wickham	x				x			
" *punctulatus* Scudder	x	x						
Carabus maeander sangamon Wickham	x				x			

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Cymindis aurora Scudder	x	x						
" *extorpescens* Scudder	x						x	
Dicaelus alutaceus Scudder	x	x						
" species	x	x						
Pterostichus laevigatus Scudder	x	x						
" *longipennis* Scudder	x	x						
" *abrogatus* Scudder	x				x			
" *destitutus* Scudder	x				x			
" *fractus* Scudder	x				x			
" *destructus* Scudder	x				x			
" *gelidus* Scudder	x				x			
" *depletus* Scudder	x				x			
" *dormitans* Scudder	x				x			
Cychrus wheatleyi Scudder	x	x						
" *minor* Scudder	x	x						
Elephrus irregularis Scudder	x				x			
Loricera glacialis Scudder	x				x			
" *lutosa* Scudder	x				x			
" *exita* Scudder	x				x			
Nebria abstracta Scudder	x				x			
Bembidium glaciatum Scudder	x				x			
" *haywardi* Scudder	x				x			
" *vestigium* Scudder	x				x			
" *vanum* Scudder	x				x			
" *praeteritum* Scudder	x				x			
" *expletum* Scudder	x				x			
" *damnosum* Scudder	x				x			
" *fragmentum* Scudder	x				x			
Patrobus gelatus Scudder	x				x			
" *decessus* Scudder	x				x			
" *frigidus* Scudder	x				x			
" *henslowi* Wickhem	x				x			
Badister antecursor Scudder	x				x			
Platynus casus Scudder	x				x			
" *hindei* Scudder	x				x			
" *halli* Scudder	x				x			
" *dissipatus* Scudder	x				x			
" *desuetus* Scudder	x				x			
" *harttii* Scudder	x				x			
" *delapidatus* Scudder	x				x			
" *exterminatus* Scudder	x				x			
" *interglacialis* Scudder	x				x			
" *subgelidus* Wickham	x				x			

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Platynus interitus Scudder	x				x			
" *pleistocenicus* Wickham	x				x			
" *longaevus* Scudder	x				x			
Harpalus conditus Scudder	x				x			
DYTISCIDAE								
Coelambus derelictus Scudder	x				x			
" *cribrarius* Scudder	x				x			
" *infernalis* Scudder	x				x			
" *disjectus* Scudder	x				x			
Hydroporus inanimatus Scudder	x				x			
" *inundatus* Scudder	x				x			
" *sectus* Scudder	x				x			
Agabus savagei Wickham	x				x			
Agabus perditus Scudder	x				x			
Agabus praelugens Wickham	x				x			
Species indet.							x	
GYRINIDAE								
Gyrinus confinis LeConte					x			x
HYDROPHILIDAE								
Cymbiodyta exstincta Scudder	x				x			
Hydrochus amictus Scudder	x				x			
Helophorus regescens Scudder	x				x			
STAPHYLINIDAE								
Gymnusa absens Scudder	x				x			
Quedius deperditus Scudder	x				x			
Philonthus claudus Scudder	x				x			
Cryptobium detectum Scudder	x				x			
" *cinctum* Scudder	x				x			
Lathrobium interglaciale Scudder	x				x			
" *antiquatum* Scudder	x				x			
" *debilitatum* Scudder	x				x			
" *exesum* Scudder	x				x			
" *inhibitum* Scudder	x				x			
" *frustum* Scudder	x				x			
Oxyporus stiriacus Scudder	x				x			
Bledius glaciatus Scudder	x				x			
Geodromicus stiricidii Scudder	x				x			
Acidota crenata Fabr. (var. *nigra*)					x			x
Arpedium stillicidii Scudder	x				x			
Olophrum celatum Scudder	x				x			
" *arcanum* Scudder	x				x			

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Olophrum dejectum Scudder	x				x			
" *interglaciale* Wickham	x				x			
CHRYSOMELIDAE								
Donacia stiria Scudder	x				x			
" *pompatica* Scudder	x				x			
" *elongatula* Scudder	x						x	
" *styrioides* Wickham	x				x			
" *proxima* Kby							x	x
Saxinis regularis Scudder	x						x	
TENEBRIONIDAE								
Tenebrio calculensis Scudder	x						x	
ELATERIDAE								
Fornax ledensis Scudder	x						x	
Corymbites aethiops Hbst?							x	x
CURCULIONIDAE								
Erycus consumptus Scudder	x				x			
Anthonomus eversus Scudder	x				x			
" *fossilis* Scudder	x				x			
" *lapsus* Scudder	x				x			
Orchestes avus Scudder	x				x			
Centrinus disjunctus Scudder	x				x			
SCOLYTIDAE								
Phloeosinus squalidens Scudder	x				x			
TRICHOPTERA								
PHRYGANEIDAE								
Phryganea ejecta Scudder	x						x	
DIPTERA								
Unnamed fragments							x	
VERTEBRATA								
PISCES								
SALMONIDAE								
Cristivomer namycush (Walbaum)				x				x
AMIIDAE								
Amia calva Linn							x	x
SILURIDAE								
Fragments							x	x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
CENTRARCHIDAE								
Lepomis species							x	x
Scales of fishes		x			x			
AMPHIBIA								
RANIDAE								
Rana species		x						
REPTILIA								
EMYDIDAE								
Clemmys insculpta LeConte	x	x						
" *percrassus* Cope	x	x						
Terrapane anguillulata (Cope)	x	x						
Terrapane carolina (Linn.)					?			x
Mud turtle			x					
COLUBRIDAE								
Bascanion acuminatus (Cope)	x	x						
AVES								
ANATIDAE								
Mergus serrator (Linn.)							x	x
SCOLOPAEIDAE								
Gallinago species	x	x						
PHASIANIDAE								
Meleagris superbus Cope	x	x						
Genus et species incertæ cedis				x				
MAMMALIA								
MEGATHERIIDAE								
Megalonyx wheatleyi Cope	x	x						
" *loxodon* Cope	x	x						
" *tortulus* Cope	x	x						
" *scalper* Cope	x	x						
" *leidyi* Lindahl	x	x	x					
" *jeffersoni* Desmarest	x			x	x	x	x	
Mylodon harlani Owen	x	x	?		x			
Paramylodon nebrascensis Brown	x	x						
EQUIDAE								
Equus complicatus Leidy	x	x	x	x	x			
" *fraternus* Leidy	x	x			x			

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Equus excelsus Leidy	x	x	x					
" *occidentalis* Leidy	x	x						
" *scotti* Gidley	x	x						
" *pectinatus* Cope	x	x						
" *laurentius* Hay	x		x					
" *niobrarensis* Hay	x		x					
Neohipparion gratum (Leidy)	x		x					
TAPIRIDAE								
Tapirus haysii Leidy	x	x		x	x			
TAYASSUIDAE								
Leptochoerus species	x	x						
Mylohyus nasutus Leidy	x	x		x			x	
" *temerarius* Hay	x		x					
" *pennsylvanicus* (Leidy)	x	x						
" *tetragonus* (Cope)	x	x						
Tayassu lenis (Leidy)	x				?	x		
Platygonus compressus LeConte	x	x	x		x	x	x	
" *vetus* Leidy	x	x			?			
CAMELIDAE								
Camelops kansanus Leidy	x	x	?					
" *vitakerianus* (Cope)	x	x						
Camelus americanus Wort	x	x						
" species	x		x					
Teleopterinus orientalis Cope	x	x						
CERVIDAE								
Alces americanus Clinton		?			x			x
" *shimeki* Hay	x		x					
Cervalces scotti Lydekker	x				x		x	
" *roosvelti* Hay	x			x				
" *borealis* Bensley	x				x		x	
Odocoileus virginianus (Zimm.)				x	x	x	x	x
" *laevicornis* (Cope)	x	x						
" *whitneyi* (Allen)	x					x		
Capromeryx furcifer Matthew	x	x						
Rangifer species				x				
" *caribou* (Gmelin)					x		x	x
" *muscatinensis* Leidy	x			?			x	
Cervus canadensis Erxlaben					x	x	x	x
ANTILOCAPRIDAE								
Antilocapra americana Ord		?				x		x

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
Bovidae								
Bison antiquus Leidy	x	x			x			
" *bison* (Linn.)						x	x	x
" *alleni* Marsh	x	x	?					
" *occidentalis* Lucas	x			x				
" *latifrons* (Harlan)	x			x	x	x	x	
Symbos cavifrons (Leidy)	x			x	x	x	x	
Boötherium bombifrons (Harlan)	x				x			
" *sargenti* Gidley	x						x	
Ovibos moschatus Zimm.					x	x	x	x
Aftonius calvini Hay	x		x					
Elephantidae								
Mammut americanum (Kerr)	x	x	x	x	x	x	x	
" *progenium* Hay	x		x					
Rhabdobunus mirificus (Leidy)	x		x					
Elephas primigenius Blum	x	x	x	x	x	x	x	
" *imperator* Leidy	x	x	x					
" *columbi* Falconer	x	x	x	x	x		x	
Sciuridae								
Sciurus calycinus Cope	x	x						
Cynomys ludovicianus (Ord)		?						x
Marmota monax (Linn.)						x		x
Castoridae								
Castor canadensis Kuhl		x	x				x	x
Muridae								
Peromyscus leucopus (Raf.)		x						x
Anaptogonia hiatidens Cope	x	x						
Sycium cloacinum Cope	x	x						
Microtus pennsylvanicus (Ord)						?		x
" *diluvianus* Cope	x	x						
" *speothen* Cope	x	x						
" *didelta* Cope	x	x						
" *involutus* Cope	x	x						
" *amphibius* Cope	x	x						
Fiber zibethicus (Linn.)		x					x	x
Geomyidae								
Geomys bursarius (Shaw)		x				x		x
Thomomys species		x						

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
DIPLOPORIDAE								
Zapus hudsonicus (Zimm.)		x						x
ERETHIZONTIDAE								
Erethizon dorsatus (Linn.)		x						x
CASTOROIDIDAE								
Castoroides ohioensis Foster	x	x	x	x	x		x	
" *kansensis* Martin	x		x					
OCHOTONIDAE								
Ochotona palatinus (Cope)	x	x						
LEPORIDAE								
Sylvilagus floridanus (Allen)		x		x		x		x
LEPTICTIDAE								
Anomodon snyderi LeConte	x					x		
TALPIDAE								
Scalops species		x						
SORICIDAE								
Blarina simplicidens Cope	x	x						
VESPERTILIONIDAE								
Vespertilio species		x						
URSIDAE								
Ursus americanus Pallas		x	x					x
" *procerus* Miller	x				x			
Arctodus haplodon (Cope)	x	x						
MUSTELIDAE								
Taxidea taxus (Schreber)		x						x
Mephitis fossidens Cope	x	x						
" *orthostichus* Cope	x	x						
" *obtusatus* Cope	x	x						
" *leptops* Cope	x	x						
" *mephitica* (Shaw)				x				x
Osmotherium spelaeum Cope	x	x						
Pelycictis lobulatus Cope	x	x						
Mustela diluviana Cope	x	x						
Gulo luscus (Linn.)		x						x
Lutra rhoadsii Cope	x	x						

	Extinct	Preglacial	Aftonian	Yarmouth	Sangamon	Peorian	Wabash	Recent
PROCYONIDAE								
Procyon priscus LeConte	x					x		
CANIDAE								
Canis latrans Say		x				x	x	x
" *priscolatrans* Cope	x	x						
" *latidentatus* (Cope)	x	x						
" *occidentalis* Richardson		x				x		x
" *dirus* Leidy	x			x				
" *mississippiensis* Allen	x					x		
" *indianensis* Leidy	x					x		
Dinocyon species		x						
Urocyon cinereoargentatus (Schreber)	x	x			x	x		x
FELIDAE								
Felis inexpectatus (Cope)	x	x						
" *calcaratus* Cope	x	x						
" *eyra* Desm.		x						x
Machairodus gracilis Cope	x	x						
" *mercerii* Cope	x	x						

CHAPTER XIII

SOME SUGGESTIONS FOR FUTURE STUDY

Detailed studies such as those carried on at Toronto and in the Chicago basin, should be conducted in all favorable localities once covered by postglacial waters. The correlation of the results of such investigations will go far toward clearing up many uncertainties which now surround the interpretation of certain biotic phenomena, especially relating to the early stages of the ponded waters. A number of typical localities have been studied critically stratigraphically, and maps and other data are available as guides. The more notable of these areas may be briefly considered.

GLACIAL LAKE AGASSIZ

This immense lake built up several shore lines in which a few evidences of life have been found (see page 164). The outlet thru Traverse and Big Stone lakes, as well as protected bays and shallow water regions, should contain deposits which might reveal something of the biotic history of the lake. Both in northern Minnesota and in Manitoba favorable localities undoubtedly occur. It is believed that sheltered spots on Beltrami Island of Lake Agassiz (now the Red Lake Indian Reservation) may have preserved some of the life of the lake in deposits formed during its different stages. Warren Upham's monograph. "The Glacial Lake Agassiz" is an indispensable aid in conducting investigations on the shores of this ancient lake. The county maps in the Final Reports of the Geological and Natural History Survey of Minnesota, especially volume IV, will be found very helpful in this work.

LAKE MAUMEE

The Wabash River, like the Desplaines in Illinois, served as an outlet for the first postglacial lake in Ohio and Indiana, Lake Maumee. The city of Fort Wayne is built upon a portion of the ancient outlet, much as are certain portions of Chicago's western suburban towns built on the ancient outlet of Lake Chicago. Studies in the sedimentary deposits left by the lake in this area would most likely be productive of results similar to those obtained in the Chicago region. During the Lake Maumee stage, the life, which had been crowded south of the ice sheet, undoubtedly migrated northward and occupied sheltered and shallow parts of this body of water, in the same manner as did the Chicago biota. It is perhaps not unwarranted to predict that a fauna of

naiades and other river mollusks, besides other life, will be discovered when this area is systematically studied.

Life is not to be looked for, however, in any abundance or variety, on the wave-beaten beaches, where few animals can live, and where the shells are soon reduced to fragments by the pounding of the waves; but rather in the sheltered spots, in bays, behind protecting bars and wherever fine sand or silt accumulates and affords a preserving medium for the remains of life. The silts deposited in the outlet east and south of Fort Wayne should have been admirable mediums for such preservation. At Sandusky there are several beaches which developed bars, behind which a safe habitat was afforded.[1]

LAKE WHITTLESEY

During the Lake Whittlesey stage, Defiance Bay, at the west end of the lake, probably provided a suitable habitat for the bióta, after the Fort Wayne outlet was abandoned. The vicinity of Grand Haven, Muskegon, and Grand Rapids, as well as the area covered by glacial Lake Saginaw, including the Grand River outlet, should be carefully studied for evidences of life.

LAKE WARREN

The waters of Lake Warren undoubtedly laid down numerous deposits which entombed the life of this stage. Mollusks have already been found at Badaxe and in other localities, and further search will doutless reveal many more. A small bay formed near Caro looks very promising, as does also another, smaller, bay near Flint. As a guide to the beaches and sedimentary strata of these lakes, Leverett's work "Glacial Formations and Drainage Features of the Erie and Ohio Basins" will be of great value, the areas of the old beaches being clearly mapped.

Evidences of life should also be looked for in the old glacial rivers serving as outlets for Lake Saginaw, especially the Imlay outlet channel connecting Lake Saginaw with Lake Chicago. The outlet near La Peer, because of its width and the apparent shallowness of the water, should contain many shallow-water forms of life. The glacial river bed, between the second and the third moraines, should contain the evidences of a naiad fauna. These outlets are well illustrated on plate vi, of Taylor's paper in the Geological Survey of Michigan.[2] The Ann Arbor Folio[3] covers much of the same region and accurately maps the old beaches and bars. In Monroe County good maps are shown;[4] also

[1] Leverett, Monograph, XLI, plate 22.

[2] Rep. State Board of Geol. Surv., Mich., 1901, pp. 111-117.

[3] U. S. Geol. Surv., Atlas, No. 155.

[4] Geol. Surv. Mich., VII, Pt. 1, 1900, plate xiii, p. 140, et seq.

in a report on the Geology of Arenac County.[5] Leverett and Taylor,[5a] in the Pleistocene of Indiana and Michigan, map this region and provide a wealth of information. Several excellent maps, tho old, appear in volumes I and II of the Geological Survey of Ohio. In volume II, page 58, lagoon or swamp deposits are indicated behind beaches near Cleveland.[6]

LAKE CHICAGO

In the southern part of the Chicago outlet the body of water known as Lake Kankakee should be thoroughly searched for evidences of life which may have migrated up the Illinois-Kankakee rivers.[7] The Green Bay region is also worthy of attention and studies similar to those carried on in the Chicago region would doubtless be productive of important results.

LAKE DULUTH

The waters of this portion of the Lake Superior basin were probably purely glacial and there is little hope of finding the remains of life in the sediments laid down by this body of water. The silts of the St. Croix outlet, however, should be carefully examined.

LAKE IROQUOIS

Fossils have been found in this beach at several Canadian localities, but with the exception of the Niagara River deposits, no records have been seen from localities on the American side of the Lake. Hall has recorded Unios from this beach, but no species have been listed (see ante, page 147). The remains of life doubtless occur but have not yet been recorded. Fairchild has mapped the ancient shore of Lake Iroquois, as well as of the other glacial waters, and his report on "Glacial Waters in Central New York"[8] will be found very helpful to anyone studying the life which may be found in or near these beaches. Leverett[9] publishes an admirable map of the Pleistocene features of northwestern New York, which clearly indicates the area of the Iroquois beach and lake. Coleman[10] (Iroquois Beach in Ontario) also gives an excellent map showing the position of this beach in Ontario and New York. The region of Sodus Bay, as well as the whole of western Lake Ontario and the eastern portion of

[5] Mich. Geol. and Biol. Surv., No. 11, 1912.

[5a] Monograph LIII, U. S. G. S., 1915.

[6] Vol. II, p. 61. See also Carney, Bull. Sci. Lab. Denison Univ., XIV, pp. 262-287, 1909. for shore lines of Maumee, Whittlesey and Warren waters.

[7] See Leverett, Illinois Glacial Lobe.

[8] Bull. N. Y. State Mus., No. 127, 1909.

[9] Monograph XLI, plate iii.

[10] Bull. Geol. Soc. Amer., XIV, pp. 347-368, 1904.

Lake Erie, is well mapped and described by Fairchild in his paper "Glacial Waters in the Lake Erie Basin."[11]

The Ridge Road north of Rochester, and particularly the old Irondequoit Bay silts, should produce evidences of the life of the Lake Iroquois stage. The region has been mapped and described by Fairchild.[12] The bed of glacial Lake Tonawanda[13] is also worthy of study. The old glacial outlets near Syracuse, especially the region of the Montezuma marsh, should contain some evidences of postglacial life, as should also parts of the old Mohawk-Hudson outlet.

LAKE ALGONQUIN AND THE NIPISSING GREAT LAKES

The silts of the Trent outlet as well as those of the Nipissing-Ottawa (North Bay) outlet should be examined. It is possible that certain marine organisms (as *Mysis*, *Pontoporeia* etc.) may have migrated into the present Great Lake system at this time, from the Champlain Sea. The postglacial distribution of a number of animals, notably the naiades, might be far better understood if a naiad fauna could be found in these outlets.

INTERGLACIAL DEPOSITS

Interglacial deposits may be looked for in many places south of the Wisconsin drift sheet. North of this till reliance can only be placed on well drillings or deep stream cuttings.

Iowa

In Iowa, deposits referable to the Aftonian, Yarmouth, Sangamon and Peorian intervals are known. The reports of the Iowa Geological Survey serve as admirable guides for the stratigraphical location of these deposits. In not a few places several of these horizons are superimposed and reasonable care will place the biotic remains found in strata of undoubted age. Many rivers, which cut thru the upper drift, expose the earlier tills and interglacial deposits in their banks.

Illinois

In Illinois the Yarmouth, Sangamon, and Peorian intervals occur, with possibly the Aftonian. Along the Fox and Illinois rivers many excellent sections may be found, penetrating all the Pleistocene deposits and entering the underlying bed rock strata. In these valleys the Illinoian and Wisconsin drift sheets are separated by the Sangamon soil, which affords excellent material for the study of some phases of the life of this interval. Along the Mississippi

[11] Bull. N. Y. State, Mus., No. 106.

[12] The Geology of Irondequoit Bay, Proc. Roch. Acad. Sci., III, pp. 236-239, 1906; see also Bull. N. Y. State Mus., No. 114, 1907.

[13] Niagara Folio, U. S. Geol. Surv., No. 190.

River, in the region of the overlap of the Kansan and Illinoian drift sheets, both the Yarmouth and the Sangamon intervals may be studied. Much work remains to be done in northwestern Illinois, where many deposists occur containing the remains of this ancient life. Leverett's maps in his "Illinoian Glacial Lobe" will be found of great assistance in this connection.

Indiana and Ohio

In many parts of these states, the old forest bed, which is believed to be of Sangamon age, is conspicuously present and may be studied with great advantage. Along the Ohio and its tributaries, many good sections occur showing the relation of this forest bed to the overlying and underlying strata. In the northern portion of Ohio, especially along the shore of Lake Erie, it is believed that interglacial deposits occur, and sections should be studied and published confirming this statement. For this work, Leverett's report on this region will be found indispensable.[14]

South Dakota, Minnesota and Wisconsin

These states, being covered for the most part by Wisconsin drift, afford splendid opportunities for the study of glacial phenomena. Old soils as well as old lake and swamp deposits should occur beneath this till. Winchell's Final Reports[15] contain many good maps of this region. The Driftless area in these states should also be carefully studied, to ascertain if possible the age of the fauna contained in the limestone crevices and beneath the loess deposits bordering the Mississippi River.

RELIABILITY OF DATA

Too strong an emphasis cannot be placed on the admonition to use the greatest amount of care in studying and reporting data of this character. Accuracy of detail is absolutely essential. In making sections, every variation no matter how small, should be noted on a chart, and any material obtained should be correspondingly labeled and carefully preserved for future reference. The character of overlying and underlying till, if these are thot to be present, should be established with reasonable certainty.

It is eminently desirable that all material collected and upon which determinations have been made, should be deposited in some well-known and accessible museum, that it may be available for study by subsequent workers. By this precaution previous errors of identification may be corrected. Many times changes of nomenclature cause confusion in interpreting older records; also composite species, later broken up into several species, perplex the subsequent investigator. In short, the greatest effort should be made to make the story of Pleistocene life as true and complete as possible.

[14] Monograph, No. XLI, U. S. Geol. Surv.

[15] Minnesota Geological and Natural History Survey.

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The list of works indicated below includes all of the references consulted during the preparation of this volume. It is believed to contain all of the important references to the presence of life during the Pleistocene, as related to the area limited in the preface. Absolute completeness is not claimed. The measure of its fullness can be known only after its use by students of the subject.

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DESCRIPTION OF PLATES

Plate I. Section of Wilmette Bay, showing variation in sedimentary strata. The character and thickness of each deposit is indicated, as is also the altitude. The level of the different water bodies is also indicated. Only a few of the most characteristic of the 63 stations are shown. The measurements of the strata are in inches. Folder at end of volume.

Plate II. Plan of North Shore Channel, showing location of stations.

Plate III. Longitudinal section of North Shore Channel, from Foster Avenue to Lincoln Avenue, showing relation of the ground moraine to the sedimentary strata and indicating location of section stations.

Plate IV. Cross sections of Toleston beach on the Northwestern University Campus, Evanston.

Plate V. Station 1. The Unio bed may be plainly seen in the photograph. Photograph by Woodruff.

Plate VI. Station 2. The division between the surface soil and the peaty soil (strata viii-x) is indicated by the rule laid horizontally. The Unio bed is marked by the paper (III). Photograph by Woodruff.

Plate VII. Station 9. The log near the white cardboard is in sand and silt (strata iii-vii). The Unio bed above is in stratum viii. Shells were notably abundant near this old log. Photograph by Woodruff.

Plate VIII. Station 15. The Unio bed is just beneath the large boulder to the left. The latter may have been brought to this locality in a piece of ice in the spring, and dropped on the Unio bed. The deposit beneath the 15 inches of gravel and sand, upon which the Unio bed rests, is boulder clay. Photograph by Woodruff.

Plate IX. Station 16. Stratum viii, showing solid bed of shells forming a marl deposit Photograph by Woodruff.

Plate X. Station 17. The deposits are lettered from A to M as indicated in the table on page 33. Photograph by Woodruff.

Plate XI. Station 19. The height of the bank is 10 feet 8 inches. Photograph by Woodruff.

Plate XII. Station 21. A heavy bed of Unios is shown at C. Large pieces of wood were found at D. Photograph by Woodruff.

Plate XIII. Station 27. The wood in stratum ii (C) may be plainly seen beneath the gravel, sand, and Unio bed, stratum iii (B). Photograph by Woodruff.

Plate XIV. Station 28. The relation of the pond deposit (C) with its mollusks, to the lake deposit (B), with its Unio bed, is plainly indicated. Photograph by Woodruff.

Plate XV. Station 29. The relation of the sedimentary strata, indicated in the table, is here well shown. Photograph by Woodruff.

Plate XVI. Stations 29-31. General view of the canal looking south from station 32 (see plate III, 32). The vertical embankment, to the left in the photograph, extended down the center of the canal its entire length; the majority of the sections were in this embankment, which was later removed by the dredges. Photograph by Woodruff.

Plate XVII. Station 33. West bank of canal. The hammer indicates position of stratum carrying wood and *Anodonta*. Spruce cones occur in the stratum below K. Photograph by Baker.

Plate XVIII. Station 37. East bank of canal. Height of bank 15 feet. Photograph by Baker.

Plate XIX. Stations 33-37. Partly completed excavation looking north toward Devon Avenue bridge, showing one method of excavation. Photograph by Baker.

Plate XX. Station 43. The stratum of sand and gravel, separating the fossiliferous silt from the clay, is indicated by the arrow. Photograph by Baker.

Plate XXI. Station 44. The trowel, near top of picture, indicates a deposit of mollusks; the rule near the middle of photograph, indicates the position of the sandy clay (stratum iii). Photograph by Baker.

Plate XXII. Station 45. The trowel indicates the position of the sand and gravel stratum (iv). To the left, above the line, may be seen freshwater mollusks belonging to the genera *Galba* and *Planorbis*. Photograph by Baker.

Plate XXIII. Station 48. Canal looking north toward Church Street bridge. Photograph by Baker.

Plate XXIV. Station 49. There is here no sharp contact between the loamy-silt and the boulder clay. Photograph by Baker.

Plate XXV. Map of the Calumet-Sag Channel. A cross marks the location of the section described in the text.

Plate XXVI. Section of Calumet-Sag Channel. The numerals at the right indicate the relative position of the various strata. The height of the section is over 28 feet. Photograph by Woodruff.

Plate XXVII. Portion of section in plate XXVI, shown in greater detail. II, boulder clay; III, boulder pavement and Unio bed; IV, sand and gravel; note the boulders and the cross bedding in one place; V, fine gray sand; VI, clay, sandy in lower part. The sharp demarcation between the clay above and the gravel below is to be especially noted in stratum V. Photograph by Woodruff.

Plate XXVIII. Diagram illustrating the interpretation of the deposits in section of the Calumet-Sag Channel at 92nd Avenue.

Plate XXIX. Section of Rose Hill bar (part of the Calumet Beach) at Bowmanville, at the end of the bar as it turns west. Field in foreground was bed of Wilmette Bay. Photograph by Woodruff.

Plate XXX. Diagram illustrating the interpretation of the deposits in the North Shore Channel, between Foster Avenue and Lincoln Avenue.

Plate XXXI. Map of the Great Lakes region showing early stages of glacial lakes and their outlets into the Mississippi River. The different outlets were not all contemporaneous in time. Lake Jean Nicolet is hypothetical. The map indicates in a striking manner the fact that the repopulation of the territory by aquatic life was by way of the Mississippi River and its large tributaries (compiled from Leverett and Upham; cut from Baker, Mon. Lymn., fig. 3).

Plate XXXII. The Glenwood stage of Lake Chicago (after Alden).

Plate XXXIII. The Bowmanville low water stage.

Plate XXXIV. Wilmette Bay during the Bowmanville low water stage. The numerals on land (593,600, etc.) indicate altitudes above sea level; figures in the bay (5, 10, etc.) indicate probable depths of water. The names and locations of the streets of the City of Chicago in the area studied are given.

Plate XXXV. The Calumet stage of Lake Chicago (after Alden).

Plate XXXVI. Wilmette Bay during the Calumet stage. Numerals as in plate XXXIV.

Plate XXXVII. The Toleston stage of Lake Chicago. The Hammond stage did not differ materially (after Alden).

Plate XXXVIII. Wilmette Bay during the Toleston stage. Hammond stage the same. Numerals as in plate XXXIV.

Plate XXXIX. Ecological map of Braddock's Bay, Lake Ontario, near Rochester, N. Y. 30, 36, 60, depths of water in inches.

□ buildings
-.-.- swamps; water 6-18 inches deep; plants consisting of Typha, Pontederia, Sagittaria, Sparganium, Decodon, etc.
!!! Scirpus
... Castalia and Nymphaea
*** trees

Plate XL. Hook at end of sandy peninsula, east end of Braddock s Bay. Photograph by Baker.

Plate XLI. Hook at west end of Braddock's Bay. Photograph by Baker.

Plate XLII. Portion of Braddock's Bay, marsh-bordered, in which the water is from 5 to 9 feet deep. Photograph by Baker.

Plate XLIII. Typha marsh, Braddock's Bay. Photograph by Baker.

Plate XLIV. The Englewood stage of Lake Chicago (after Alden).

Plate XLV. Wilmette Bay during the Englewood Stage.

Plate XLVI. Map showing greatest extent of the Wisconsin ice sheet, also previous ice sheets. Compiled from Leverett, Taylor, and Chamberlin.

Plate XLVII. Figure 1. Map showing one of the first courses of drainage from Lake Michigan basin (Leverett and Taylor, Ann Arbor Folio, fig. 6). Figure 2. Map showing formation of Lake Chicago with its southerly outlet. The shaded area represents the glacial lake (Leverett and Taylor, Ann Arbor Folio, Fig. 7).

Plate XLVIII. Glacial Lakes Maumee and Chicago, showing southwestern outlets as well as drainage from the Green Bay basin (Leverett and Taylor, Smith. Report, 1912, fig. 2).

Plate XLIX. Glacial Lakes Chicago, Saginaw, and Whittlesey, showing drainage from Chicago, Green Bay, and Superior basins (Leverett and Taylor, Smith. Rep., 1912, fig. 3).

Plate L. Glacial Lakes Chicago and Warren, showing outlet thru Grand River to Lake Chicago (Leverett and Taylor, Smith. Rep., 1912, fig. 4).

Plate LI. Glacial Lakes Duluth, Chicago, and Lundy, showing outlets thru St. Croix, Chicago, and Syracuse channels (Leverett and Taylor, Smith. Rep., 1912, fig. 5).

Plate LII. Lake Algonquin, with Lakes Erie, Iroquois, and the Champlain Sea. Outlets at Chicago, Kirkfield (Mohawk-Hudson), and North Bay (Leverett and Taylor, Smith. Rep., 1912, fig. 6).

Plate LIII. Nipissing Great Lakes with Lakes Erie and Ontario, outlets at North Bay and Port Huron (Leverett and Taylor, Smith. Rep., 1912, fig. 8).

Plate LIV. Preglacial rivers of the lake basins (Spencer, Falls of Niagara, plate XL).

Plate LV. Preglacial drainage in the lake basins (during Tertiary time) as worked out by Professor Grabau. The direction of flow is southwestward (Geol. and Paleon. Niagara Falls, fig. 6, p. 45).

Plate LVI. Map of North America showing maximum development of the ice sheet and indicating (1, 2, 3, 4, 5) probable areas in which the life of the englaciated territory was preserved during the intervals of the Ice Age, when the areas shaded were covered with ice (Willis, Journ. Geol., XVII, p. 60).

Plate LVII. Figure 1. Portion of Vilas and Oneida counties, Wisconsin, showing topographic conditions in a typical glaciated country (from map published by Chicago and Northwestern Railroad Company). Figure 2. Portion of Driftless Area in Wisconsin, showing regular erosion in a typical unglaciated country (from map published by the Geological Survey of Wisconsin).

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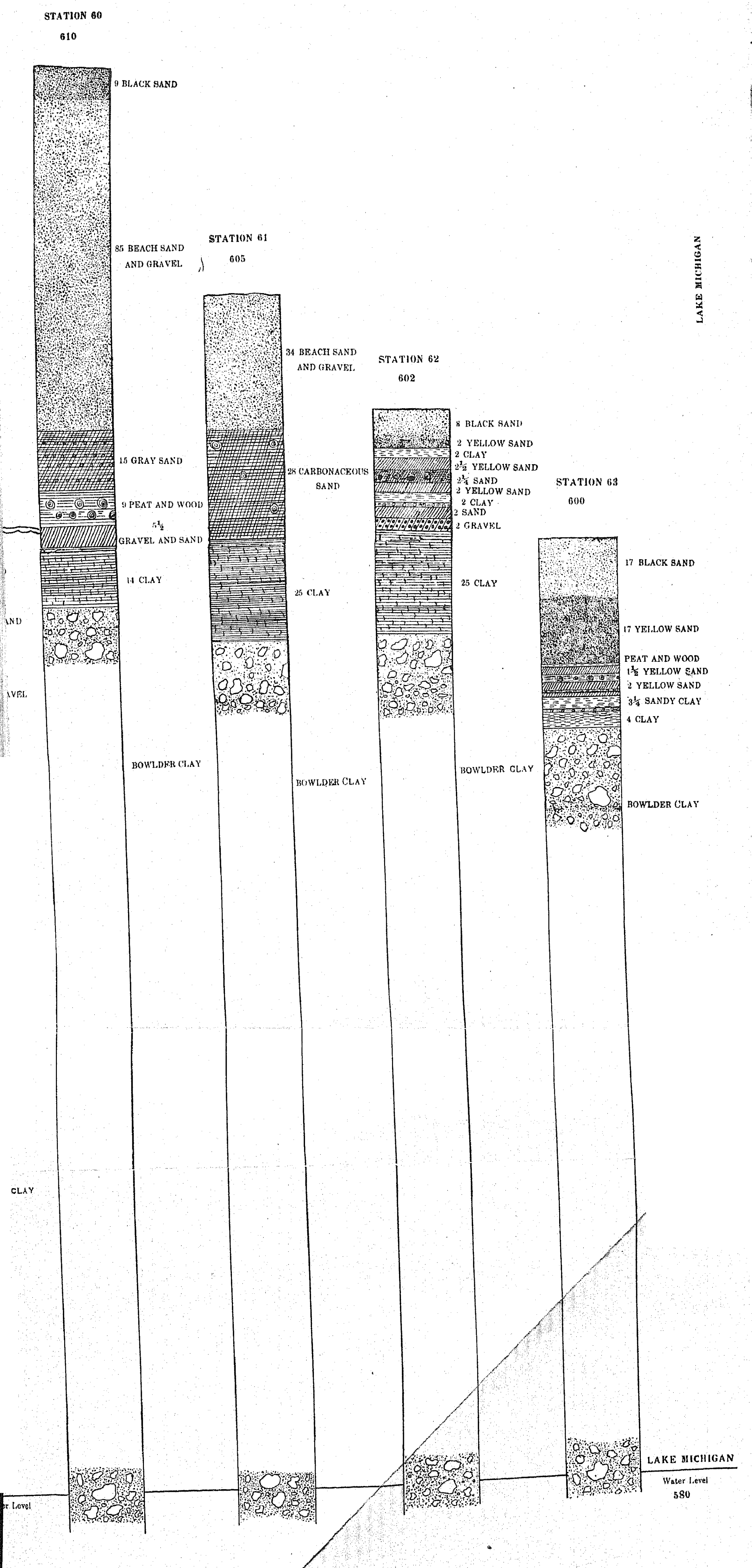
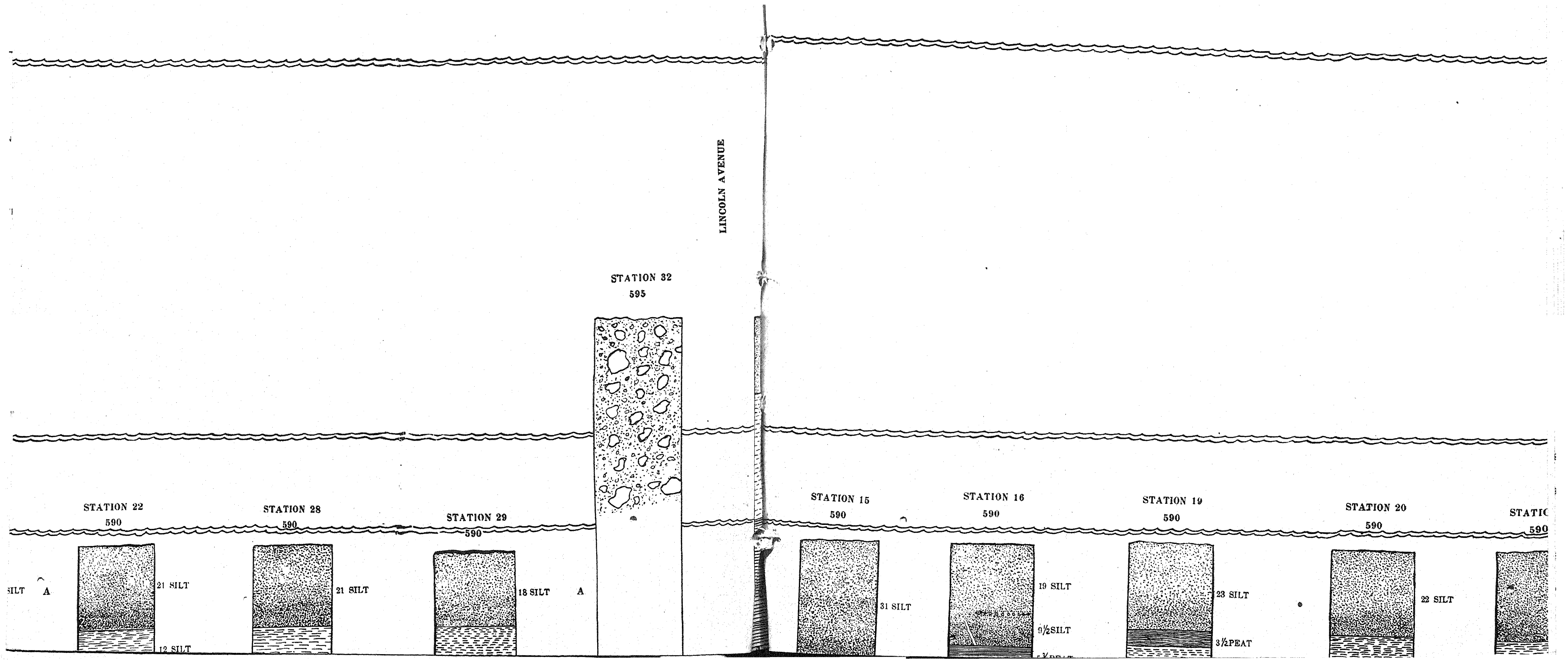
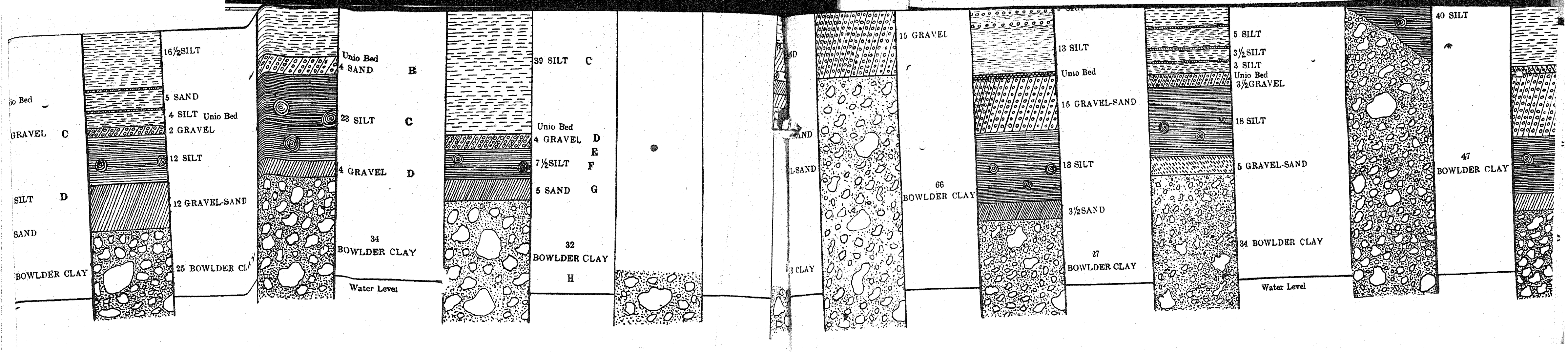
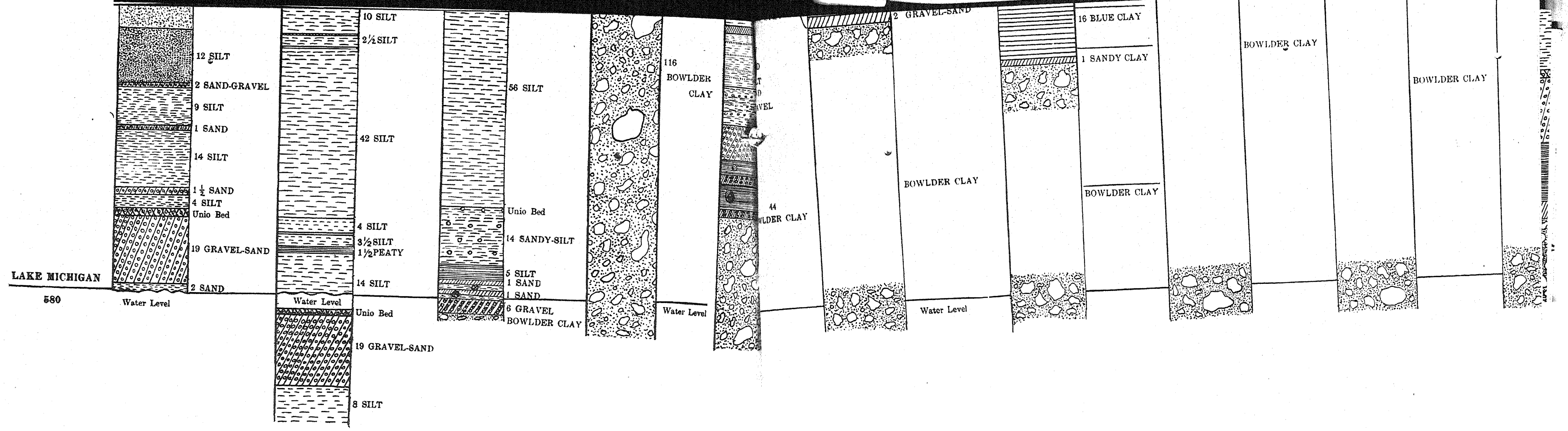


STATION 60
610
9 BLACK SAND
85 BEACH SAND AND GRAVEL
15 GRAY SAND
9 PEAT AND WOOD
5½ GRAVEL AND SAND
14 CLAY
BOWLDER CLAY
STATION 61
605
34 BEACH SAND AND GRAVEL
28 CARBONACEOUS SAND
25 CLAY
BOWLDER CLAY
STATION 62
602
8 BLACK SAND
2 YELLOW SAND
2 CLAY
2½ YELLOW SAND
2¼ SAND
2 YELLOW SAND
2 CLAY
2 SAND
2 GRAVEL
25 CLAY
BOWLDER CLAY
STATION 63
600
17 BLACK SAND
17 YELLOW SAND
PEAT AND WOOD
1½ YELLOW SAND
2 YELLOW SAND
3¼ SANDY CLAY
4 CLAY
BOWLDER CLAY
LAKE MICHIGAN
LAKE MICHIGAN
Water Level
580
CLAY

PLATE I


LINCOLN AVENUE
STATION 32
595
STATION 22
590
STATION 28
590
STATION 29
590
STATION 15
590
STATION 16
590
STATION 19
590
STATION 20
590
590
SILT
A
21 SILT
12 SILT
21 SILT
18 SILT
A
31 SILT
19 SILT
0½SILT
23 SILT
3½PEAT
22 SILT


Unio Bed
GRAVEL C
SILT D
SAND
BOWLDER CLAY
16½ SILT
5 SAND
4 SILT Unio Bed
2 GRAVEL
12 SILT
12 GRAVEL-SAND
25 BOWLDER CLAY
Unio Bed
4 SAND B
23 SILT C
4 GRAVEL D
34
BOWLDER CLAY
Water Level
30 SILT C
Unio Bed
4 GRAVEL D
E
7½ SILT F
5 SAND G
32
BOWLDER CLAY
H
15 GRAVEL
66
BOWLDER CLAY
13 SILT
Unio Bed
15 GRAVEL-SAND
18 SILT
3½ SAND
27
BOWLDER CLAY
5 SILT
3½ SILT
3 SILT
Unio Bed
3½ GRAVEL
18 SILT
5 GRAVEL-SAND
34 BOWLDER CLAY
Water Level
40 SILT
47
BOWLDER CLAY


LAKE MICHIGAN
580
Water Level
12 SILT
2 SAND-GRAVEL
9 SILT
1 SAND
14 SILT
1 ½ SAND
4 SILT
Unio Bed
19 GRAVEL-SAND
2 SAND
10 SILT
2½ SILT
42 SILT
4 SILT
3½ SILT
1½ PEATY
14 SILT
Water Level
Unio Bed
19 GRAVEL-SAND
8 SILT
56 SILT
Unio Bed
14 SANDY-SILT
5 SILT
1 SAND
1 SAND
6 GRAVEL
BOWLDER CLAY
116
BOWLDER
CLAY
Water Level
44
BOWLDER CLAY
2 GRAVEL-SAND
BOWLDER CLAY
Water Level
16 BLUE CLAY
1 SANDY CLAY
BOWLDER CLAY
BOWLDER CLAY
BOWLDER CLAY

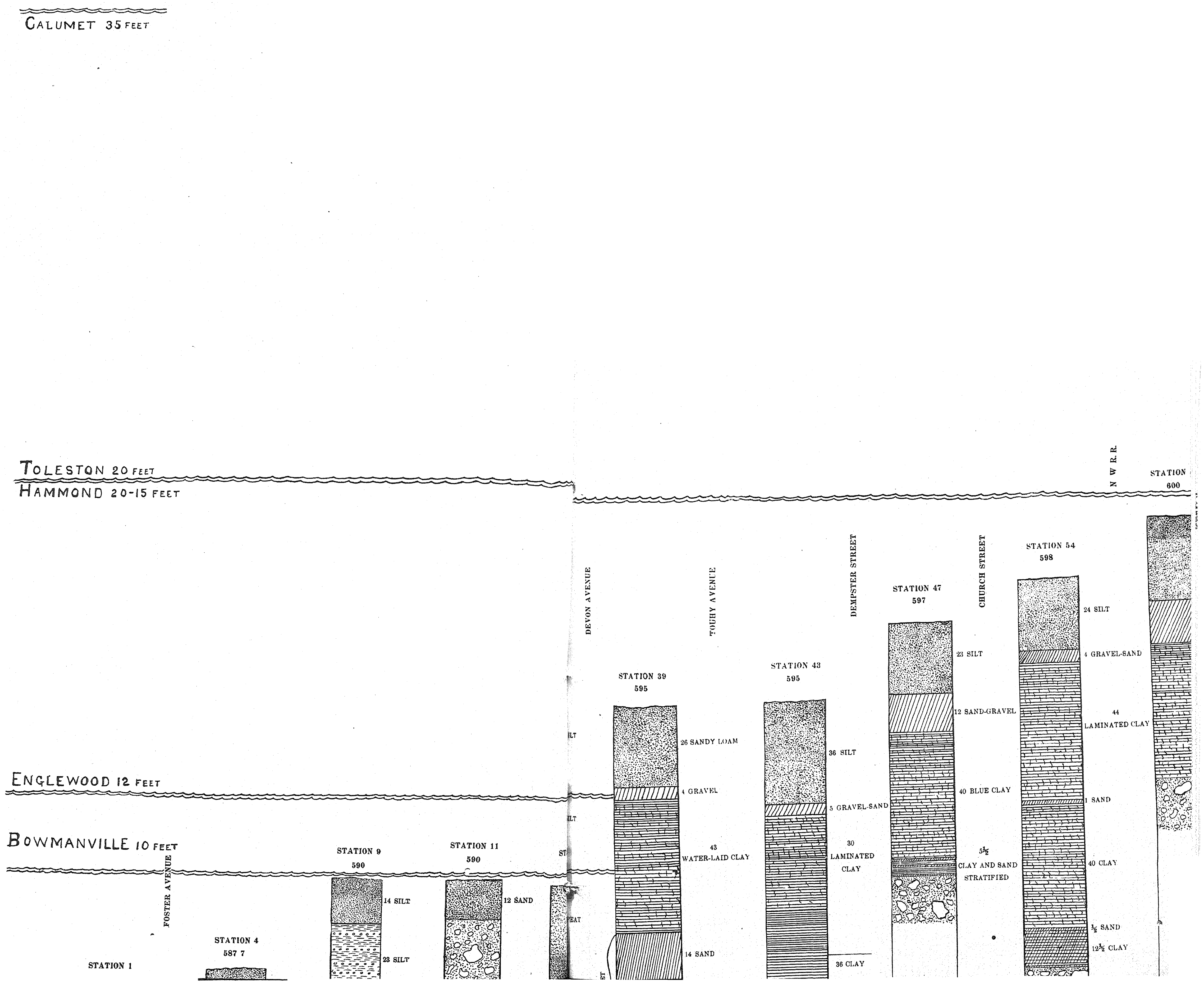

CALUMET 35 FEET
TOLESTON 20 FEET
HAMMOND 20-15 FEET
ENGLEWOOD 12 FEET
BOWMANVILLE 10 FEET
STATION 1
FOSTER AVENUE
STATION 4
587 7
STATION 9
590
14 SILT
23 SILT
STATION 11
590
12 SAND
DEVON AVENUE
STATION 39
595
26 SANDY LOAM
4 GRAVEL
43
WATER-LAID CLAY
14 SAND
TOUHY AVENUE
STATION 43
595
36 SILT
5 GRAVEL-SAND
30
LAMINATED
CLAY
36 CLAY
DEMPSTER STREET
STATION 47
597
23 SILT
12 SAND-GRAVEL
40 BLUE CLAY
5½
CLAY AND SAND
STRATIFIED
CHURCH STREET
STATION 54
598
24 SILT
4 GRAVEL-SAND
44
LAMINATED CLAY
1 SAND
40 CLAY
½ SAND
12½ CLAY
N W R R
STATION
600

PLATE II

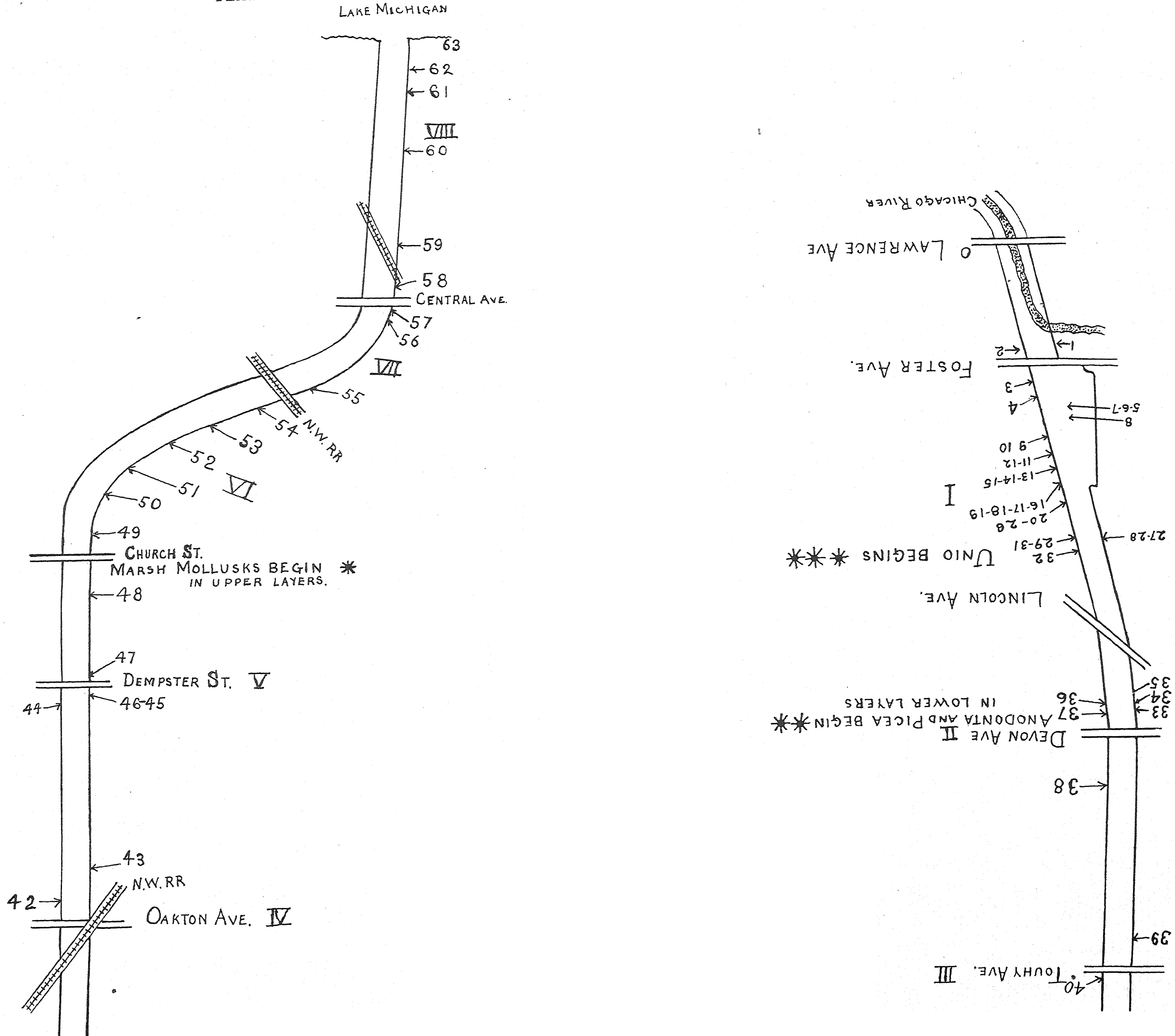
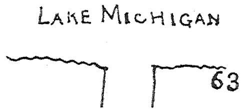
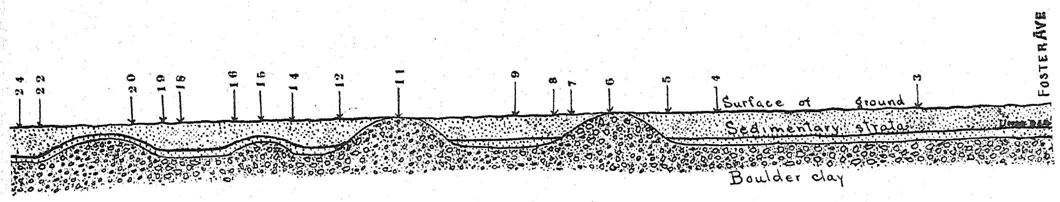

Lake Michigan
VIII
Central Ave.
VII
N.W. RR
VI
Church St.
Marsh Mollusks begin *
in upper layers.
Dempster St. V
N.W. RR
Oakton Ave. IV
Chicago River
Lawrence Ave
Foster Ave.
I
Unio begins ***
Lincoln Ave.
Devon Ave II
Anodonta and Picea begin **
in lower layers
Touhy Ave. III

PLATE II





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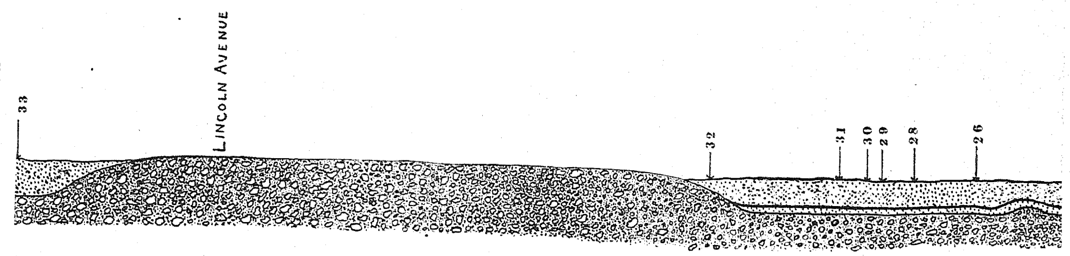

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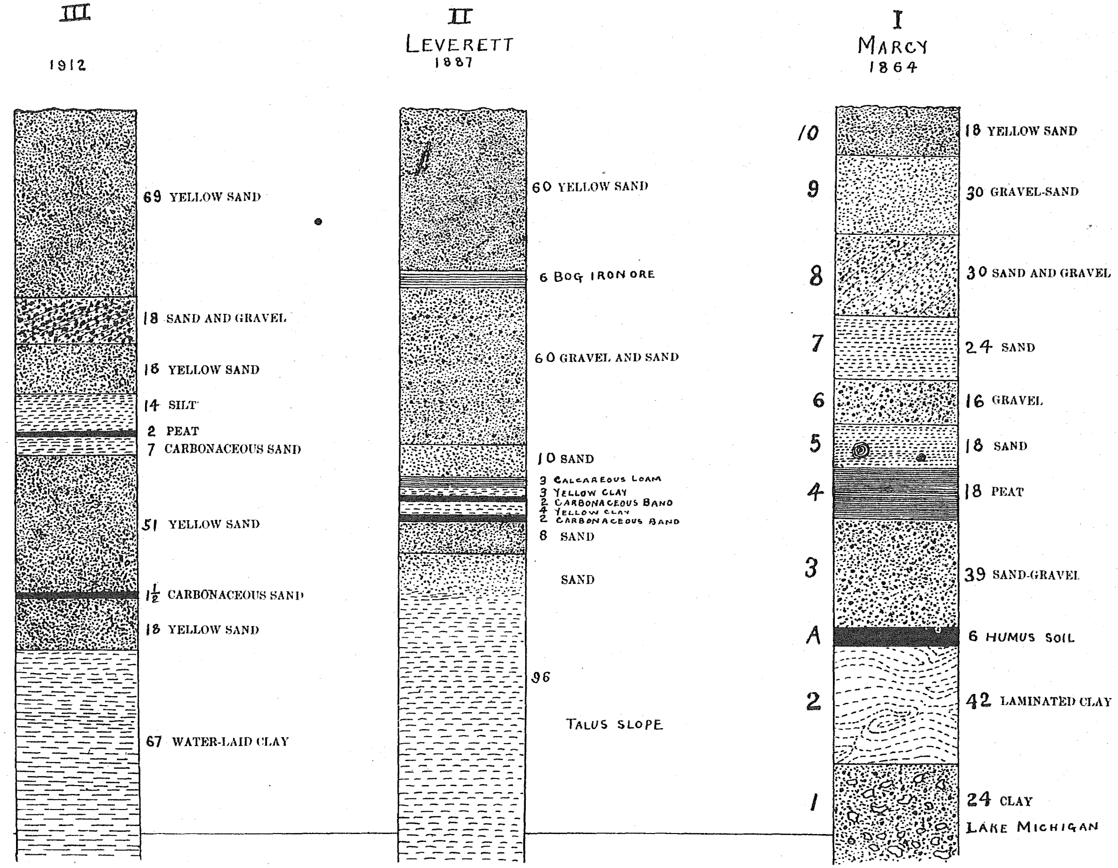

III
1912
69 YELLOW SAND
18 SAND AND GRAVEL
18 YELLOW SAND
14 SILT
2 PEAT
7 CARBONACEOUS SAND
51 YELLOW SAND
1½ CARBONACEOUS SAND
18 YELLOW SAND
67 WATER-LAID CLAY
II
LEVERETT
1887
60 YELLOW SAND
6 BOG IRON ORE
60 GRAVEL AND SAND
10 SAND
3 CALCAREOUS LOAM
3 YELLOW CLAY
2 CARBONACEOUS BAND
4 YELLOW CLAY
2 CARBONACEOUS BAND
8 SAND
SAND
96
TALUS SLOPE
I
MARCY
1864
10
18 YELLOW SAND
9
30 GRAVEL-SAND
8
30 SAND AND GRAVEL
7
24 SAND
6
16 GRAVEL
5
18 SAND
4
18 PEAT
3
39 SAND-GRAVEL
A
6 HUMUS SOIL
2
42 LAMINATED CLAY
1
24 CLAY
LAKE MICHIGAN

PLATE V

PLATE VI

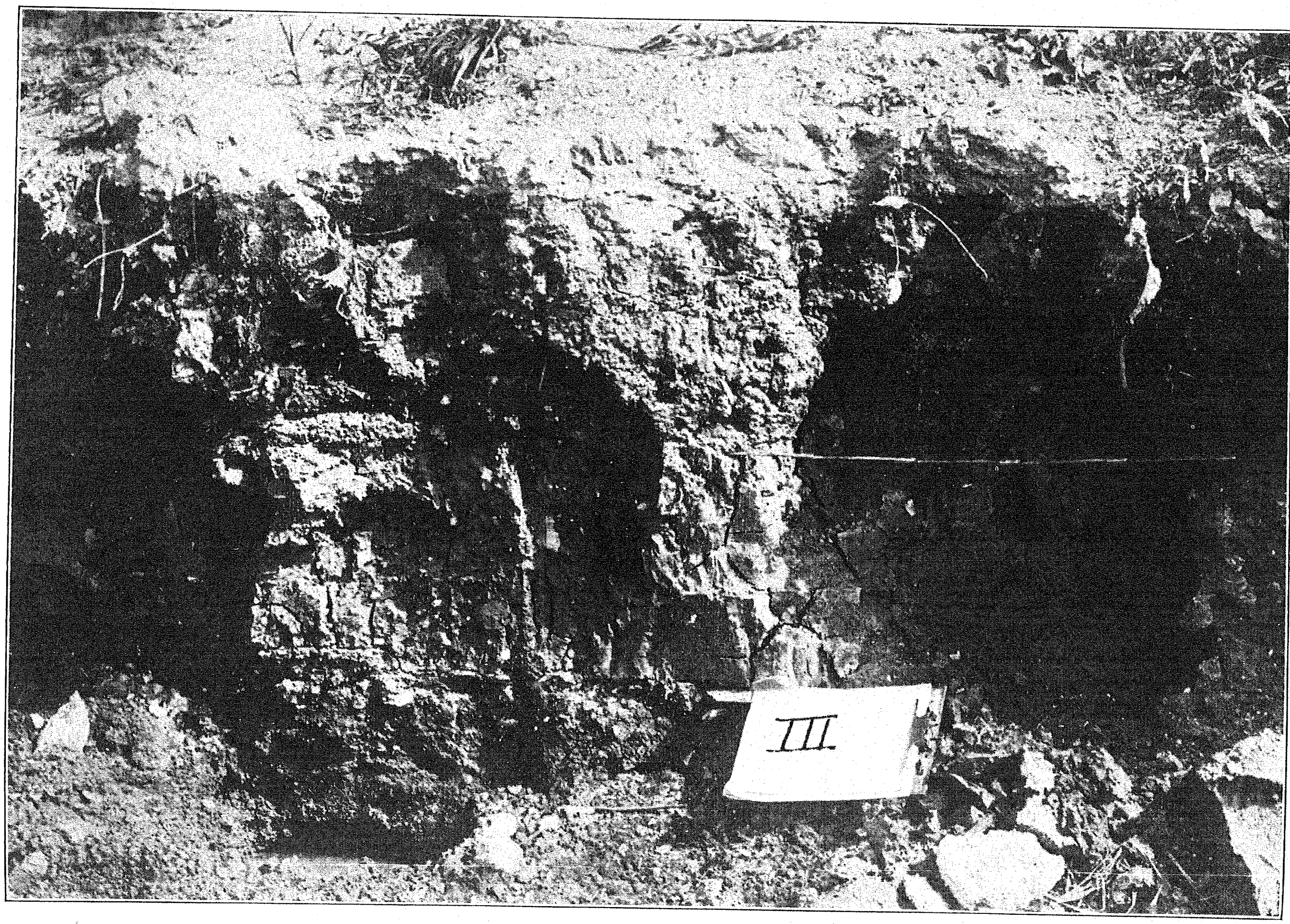
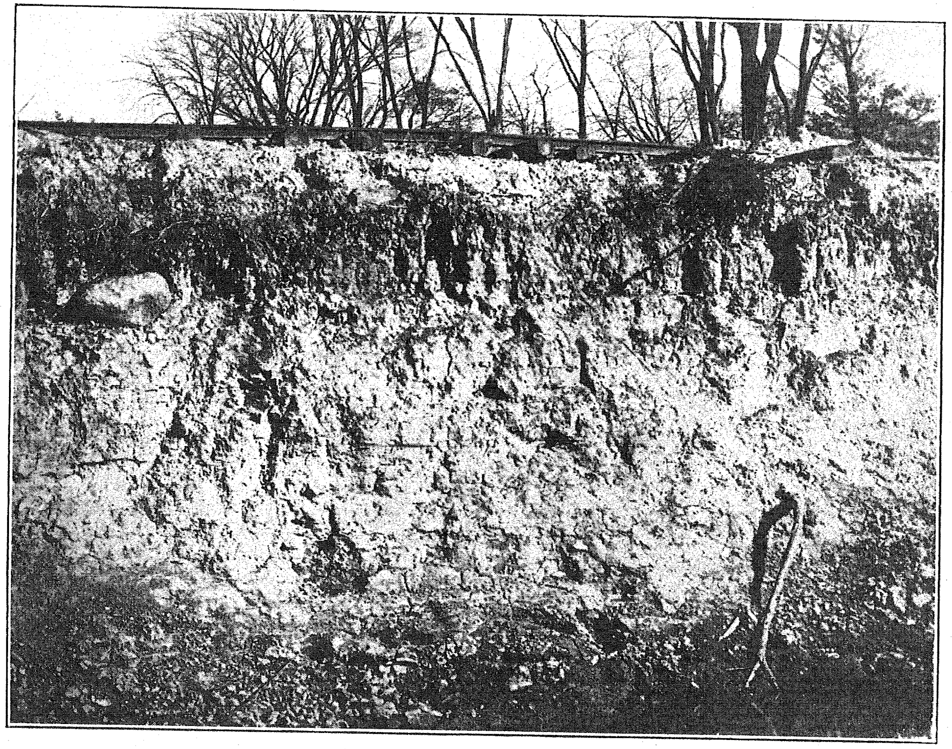


PLATE VII

PLATE VIII



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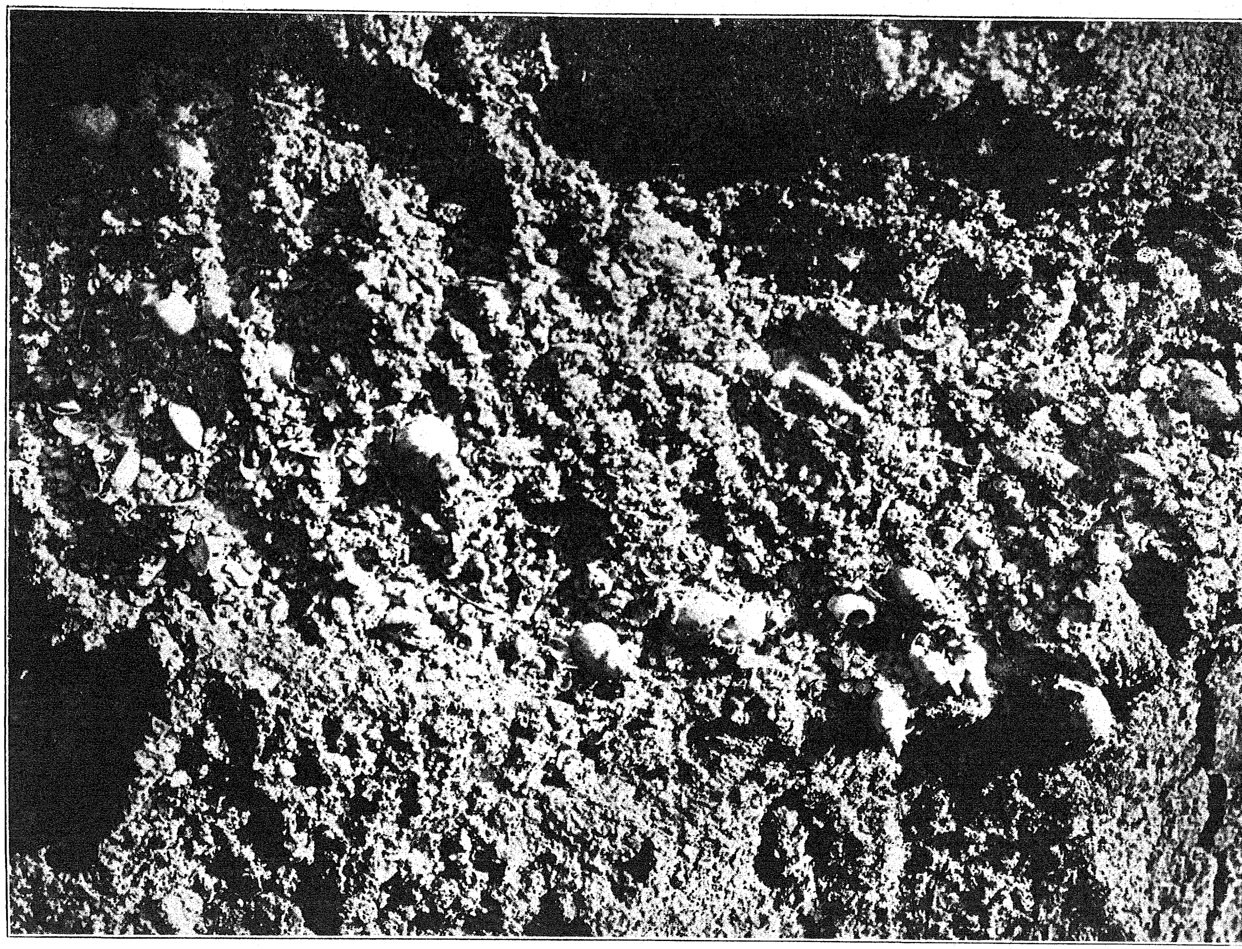

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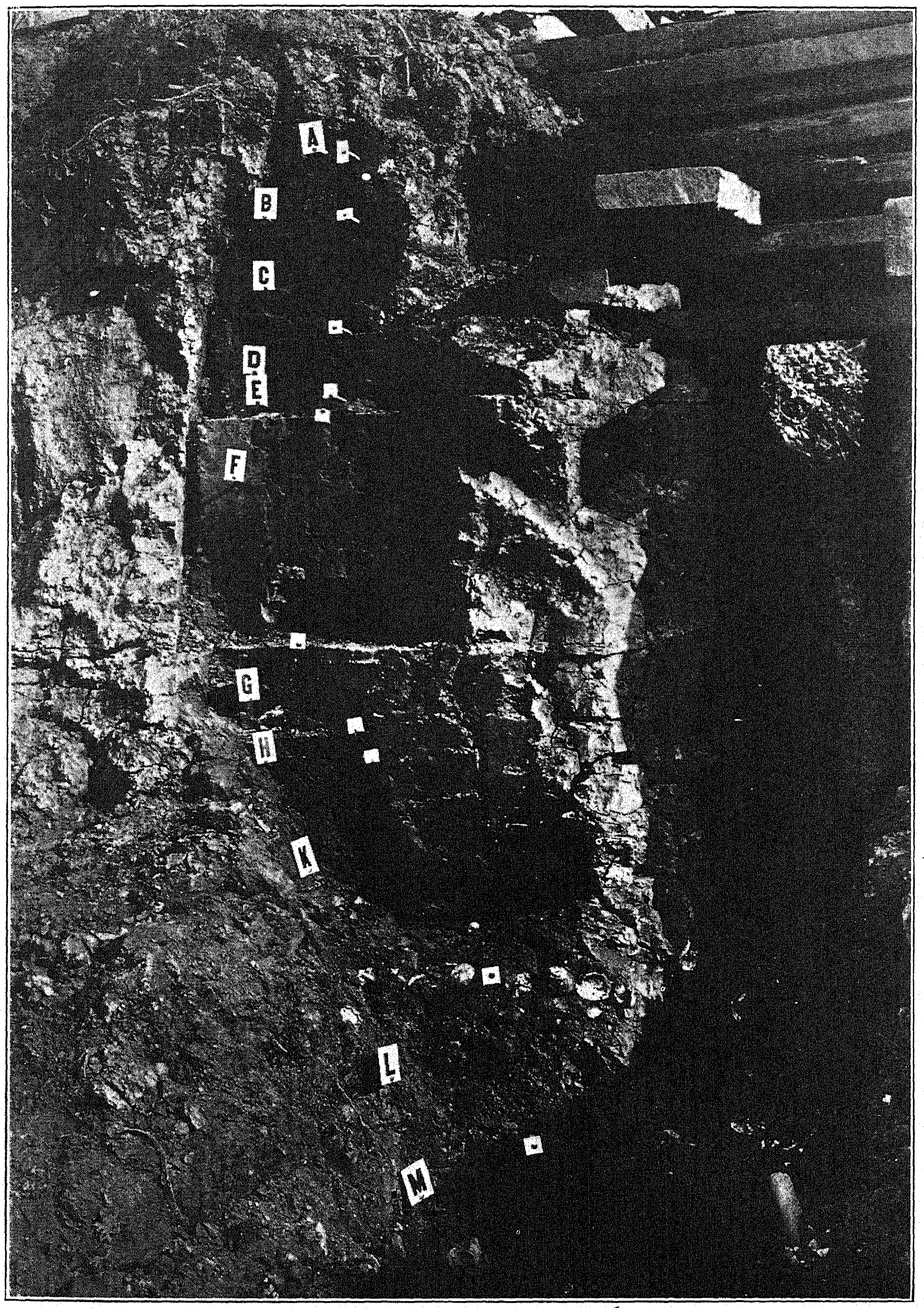

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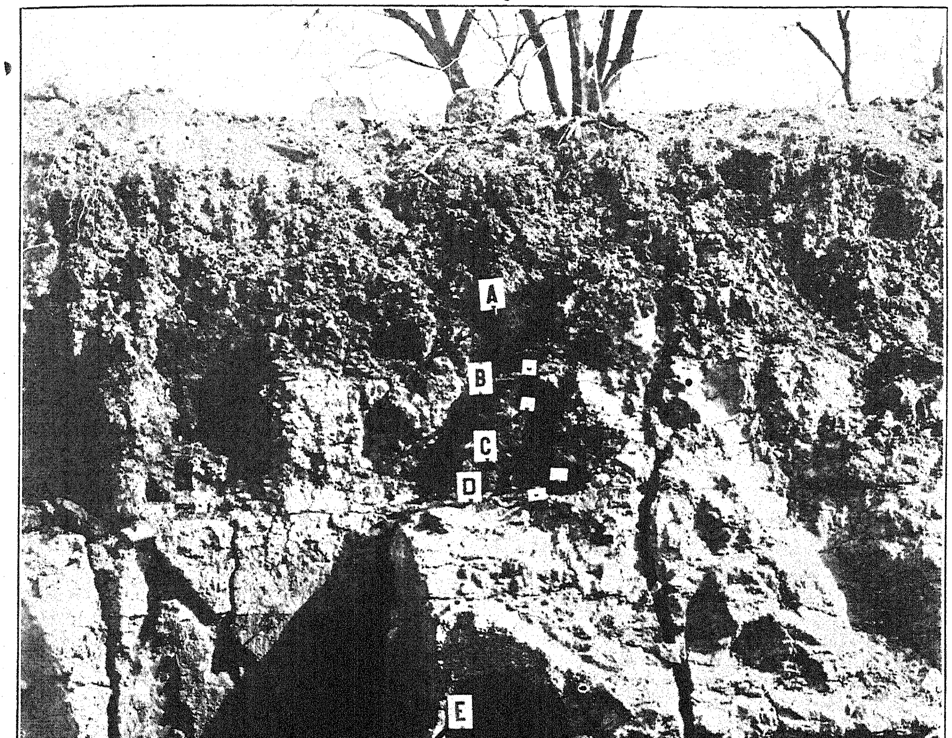
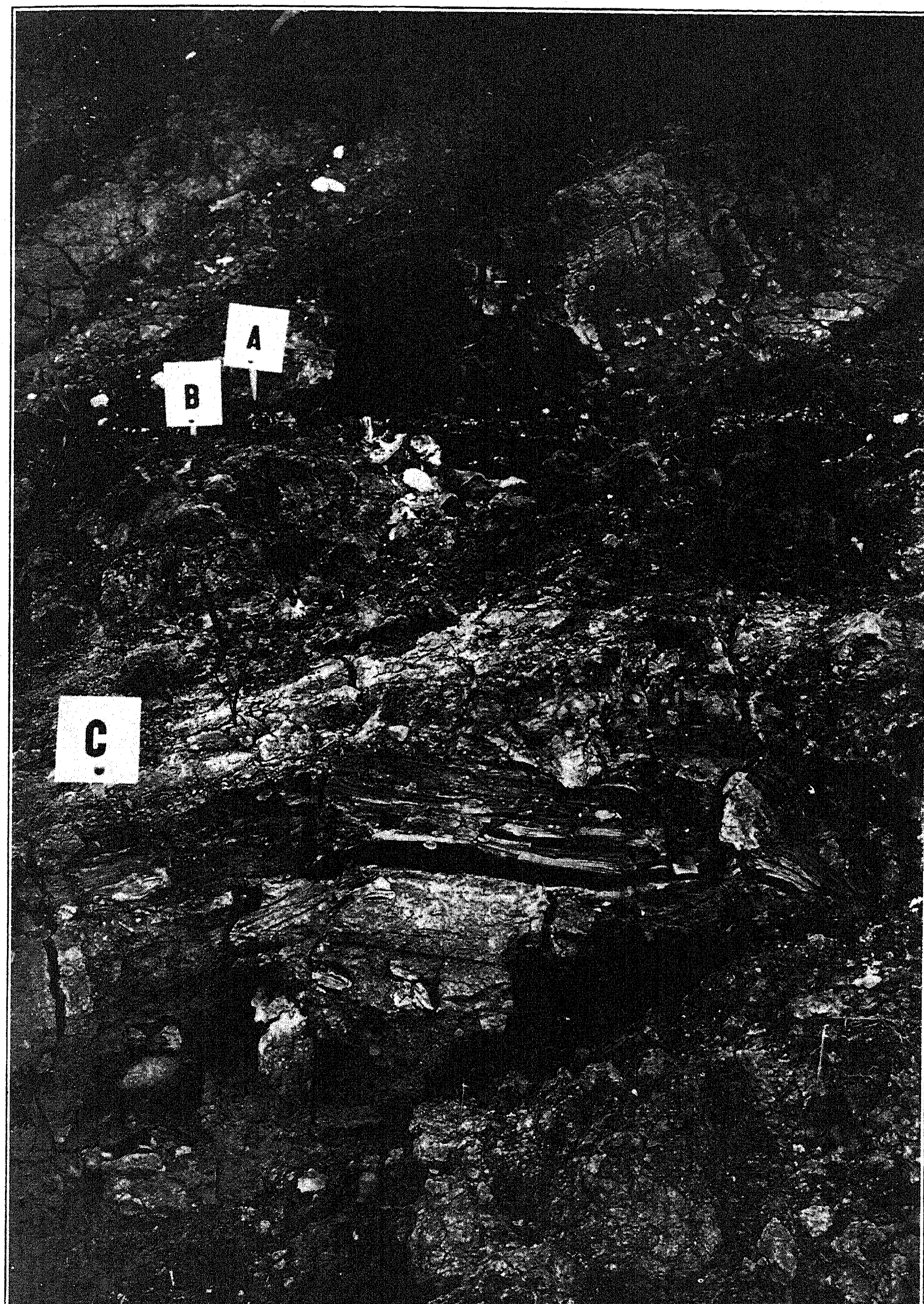


PLATE XII

PLATE XIII



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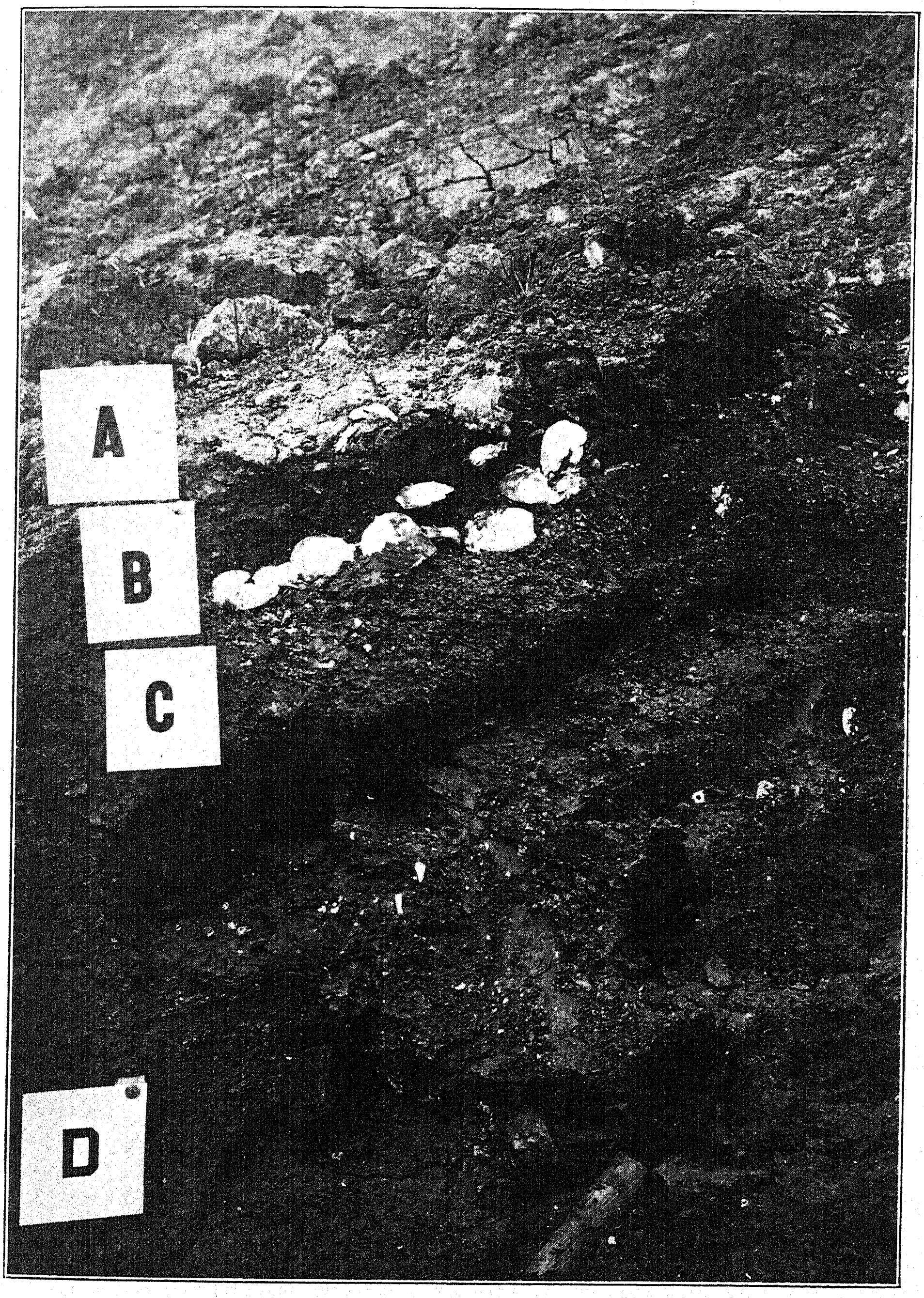

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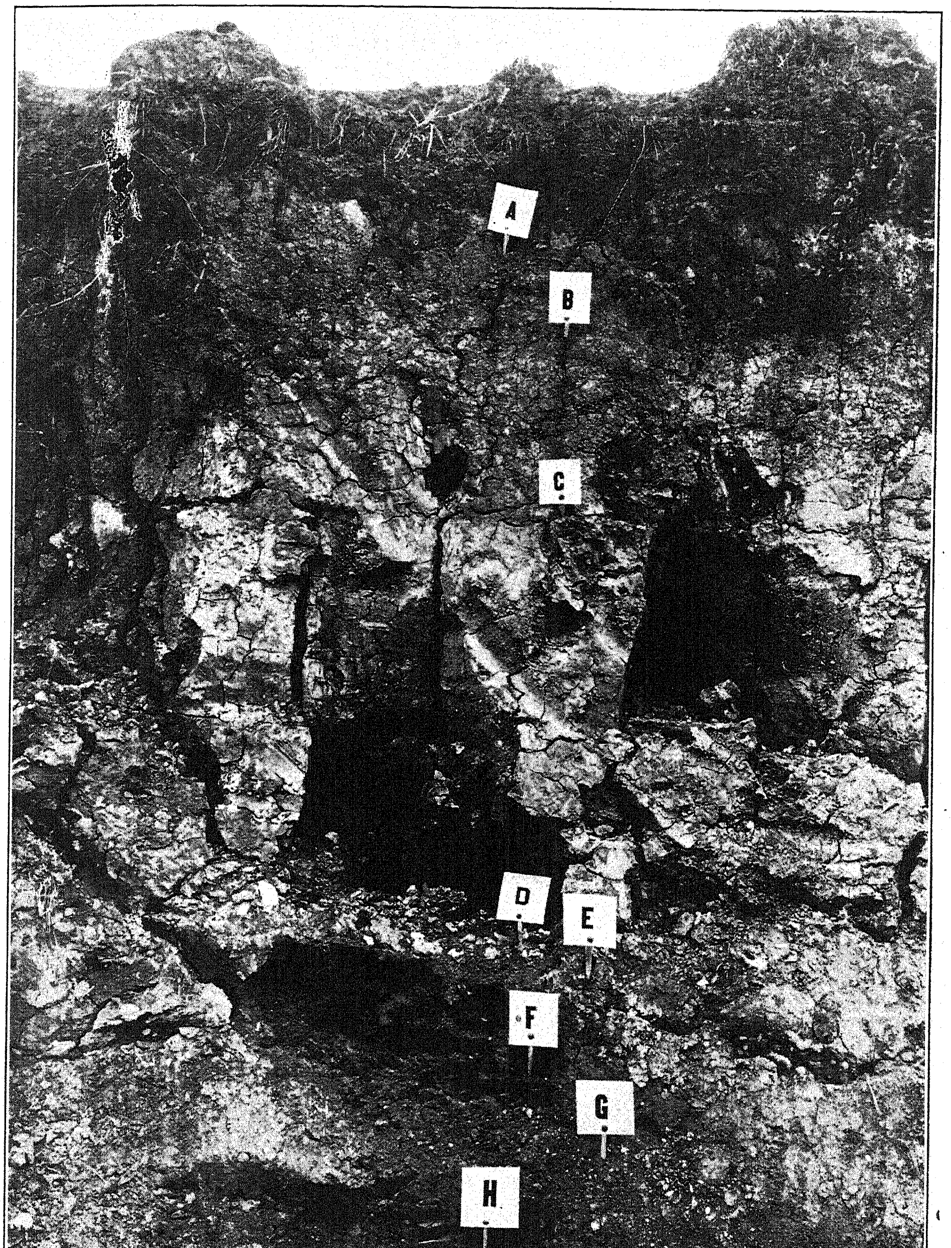

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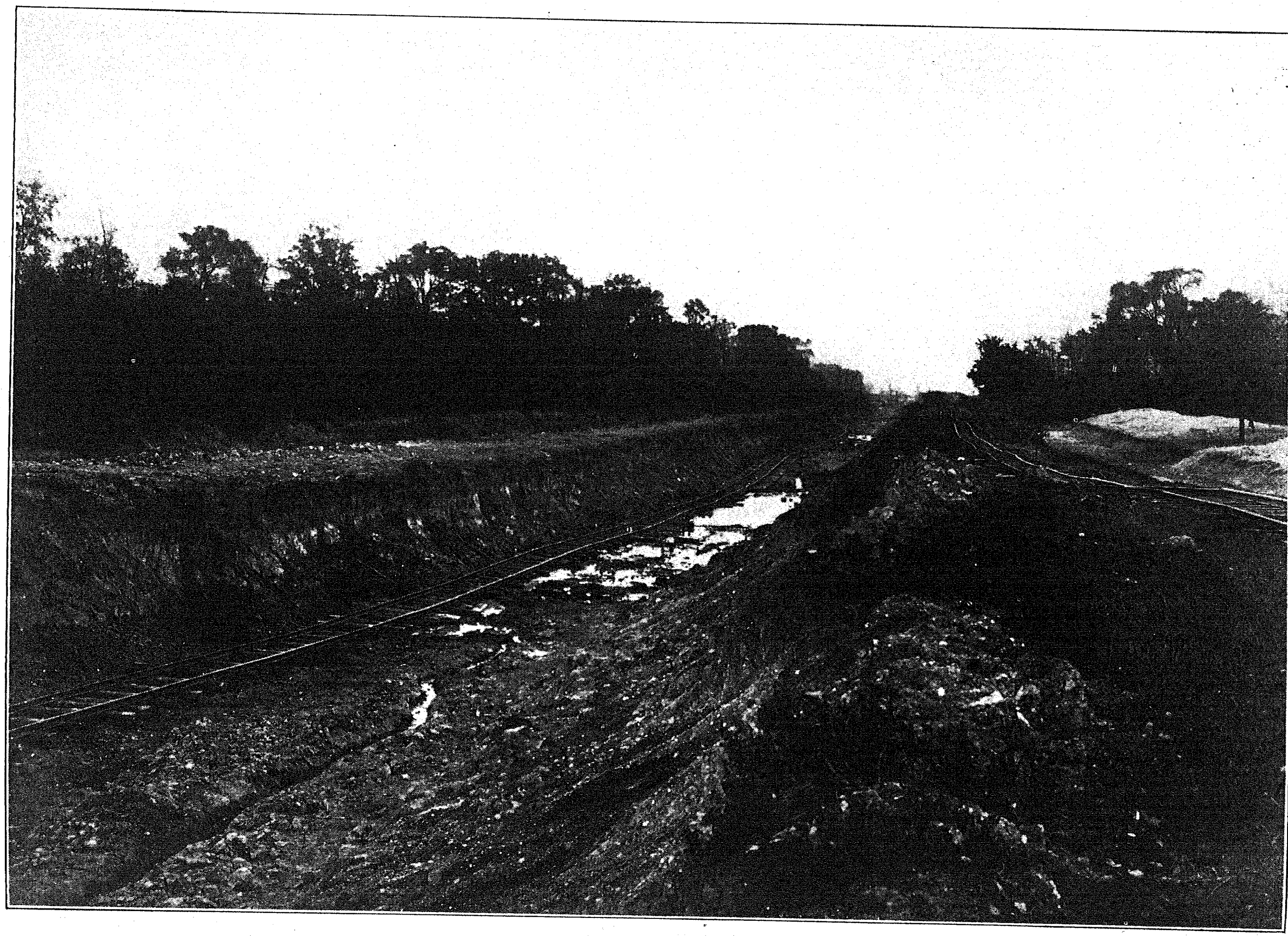

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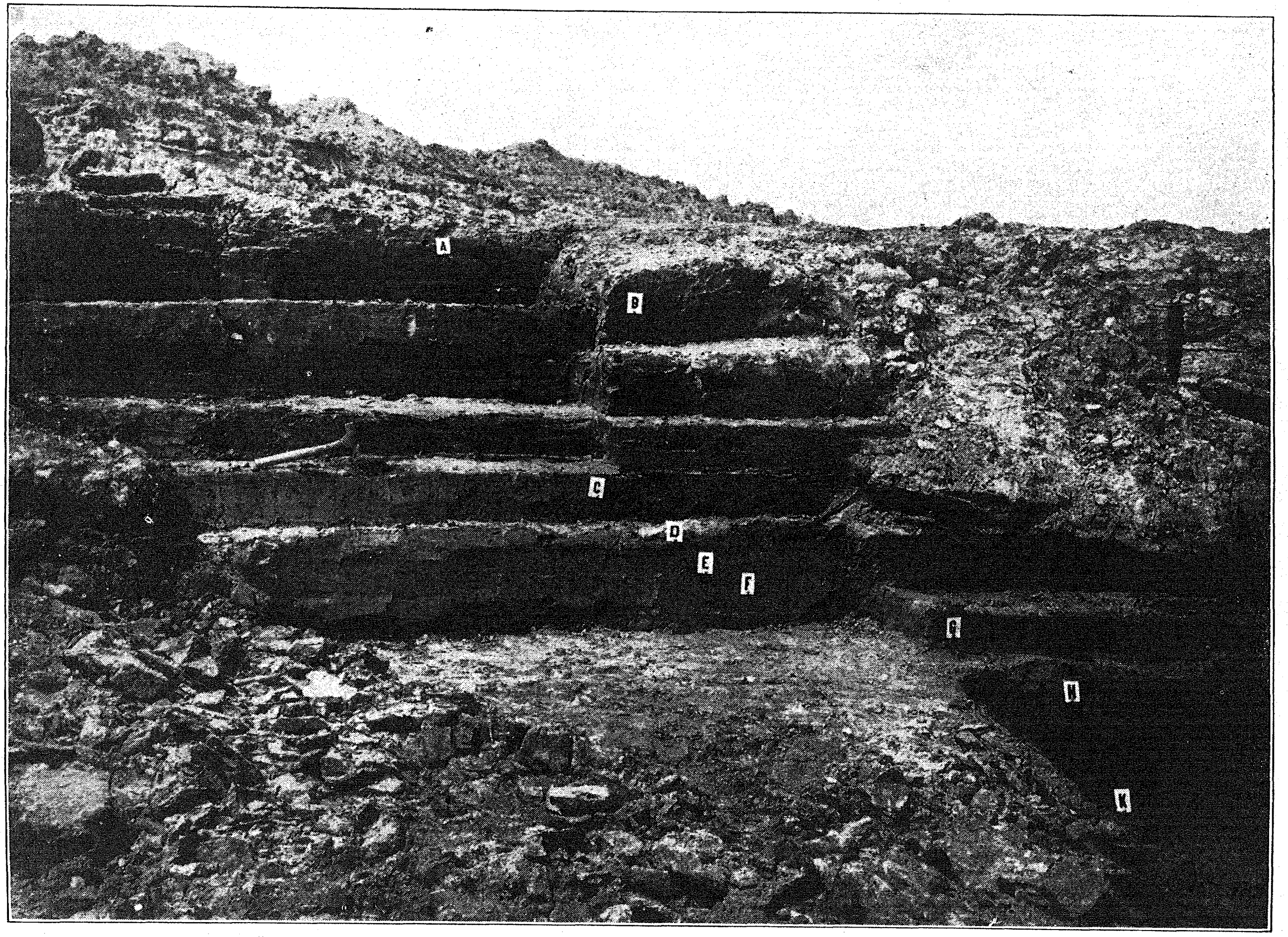

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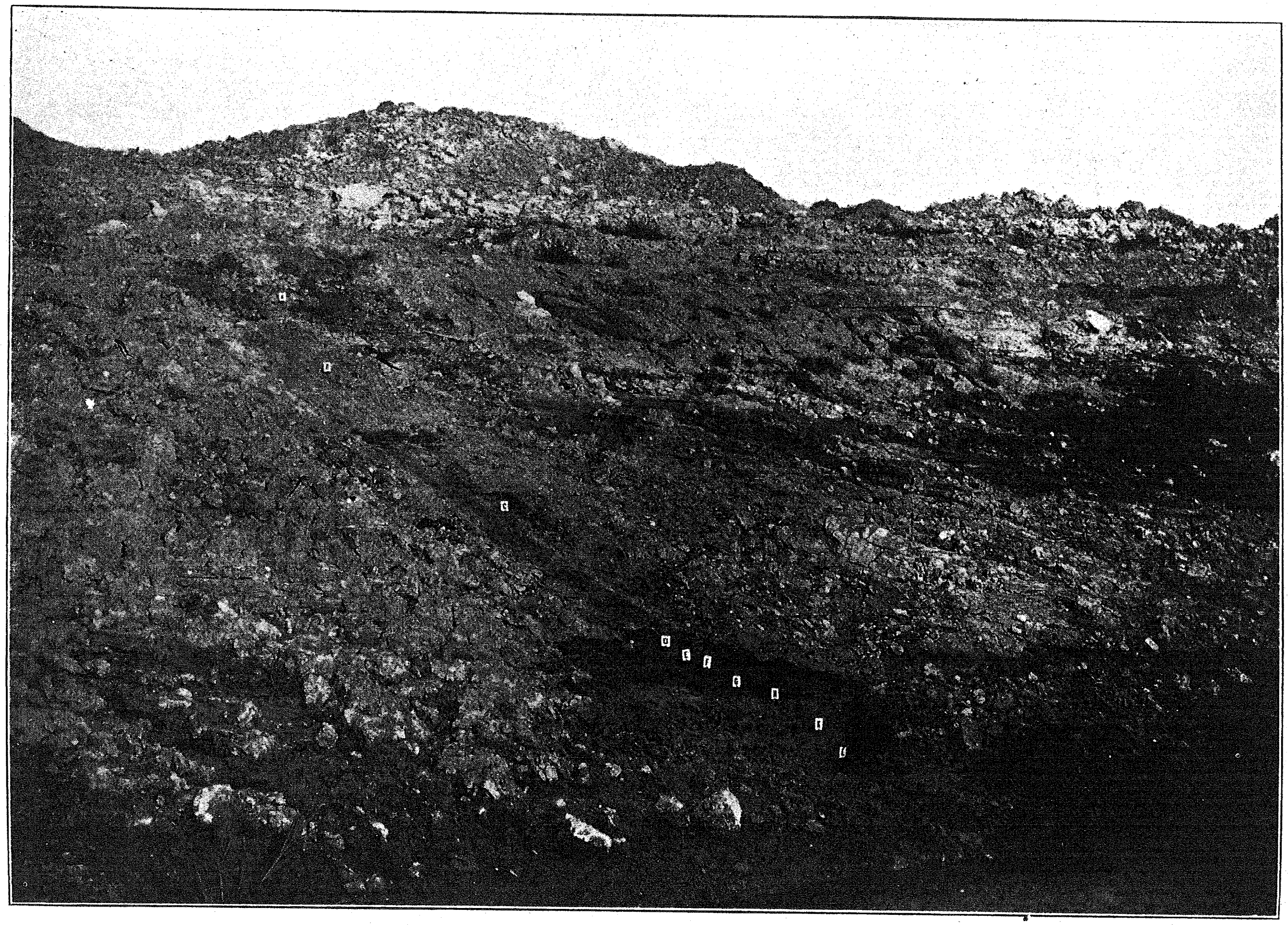

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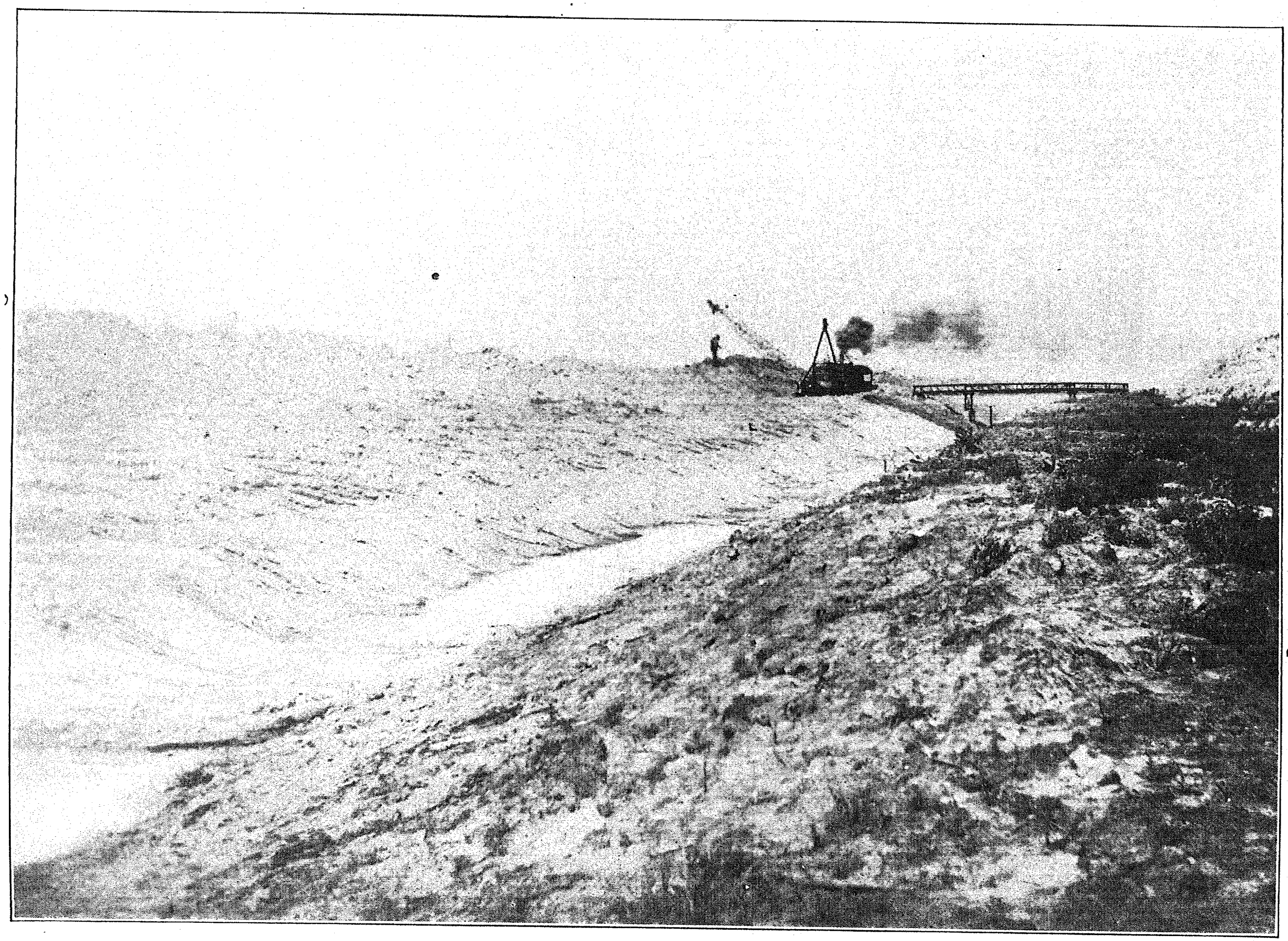

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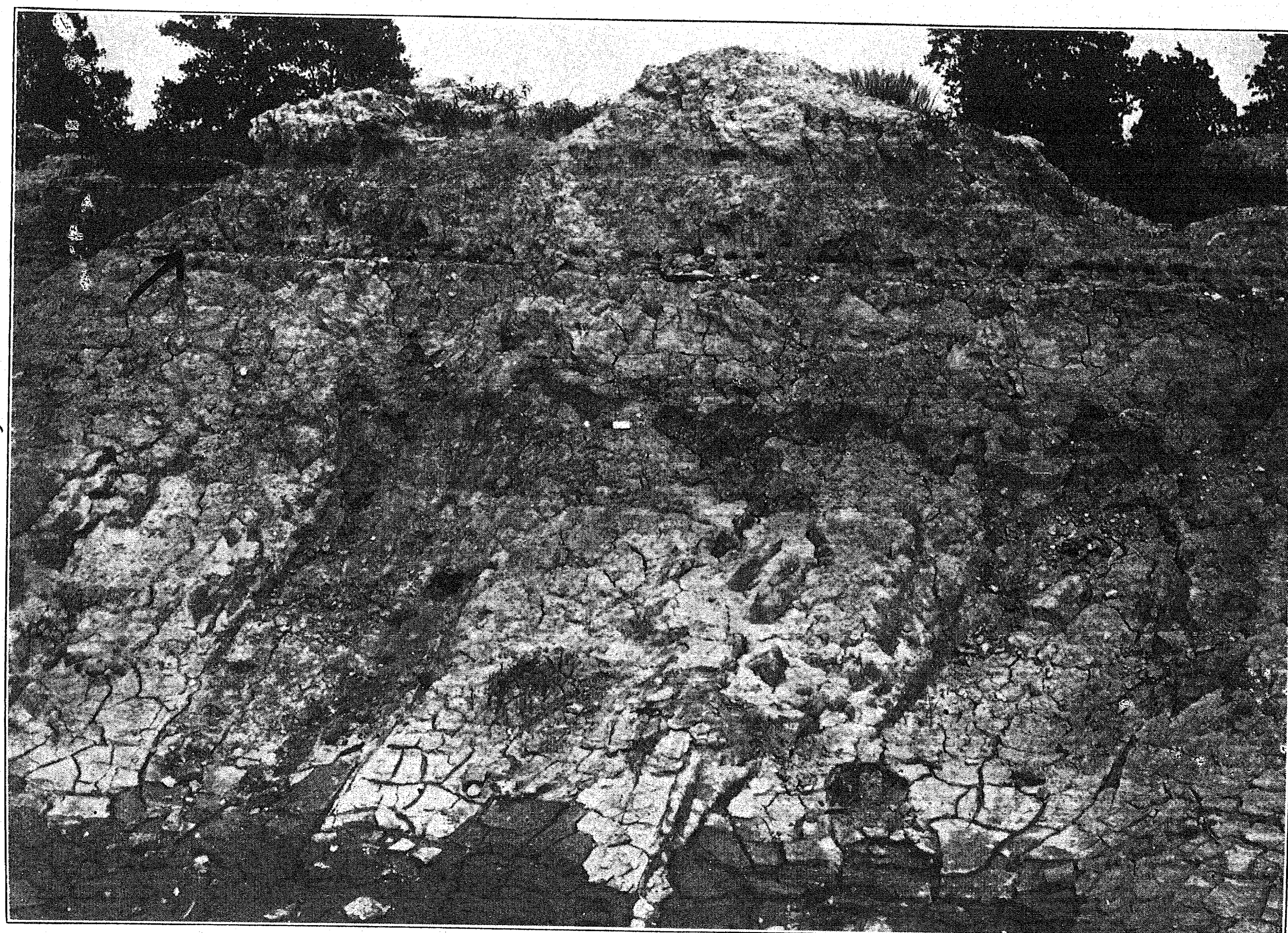

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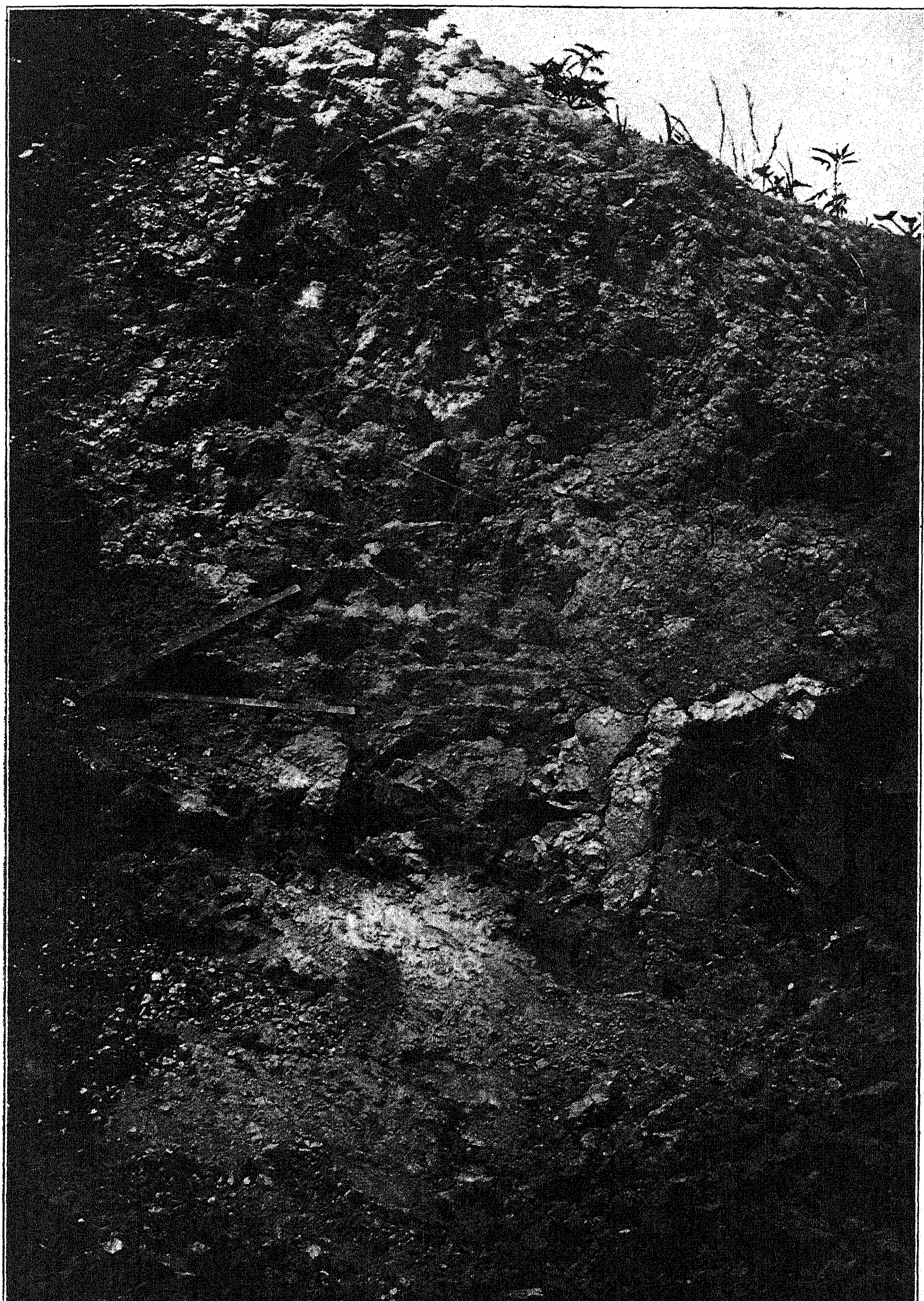

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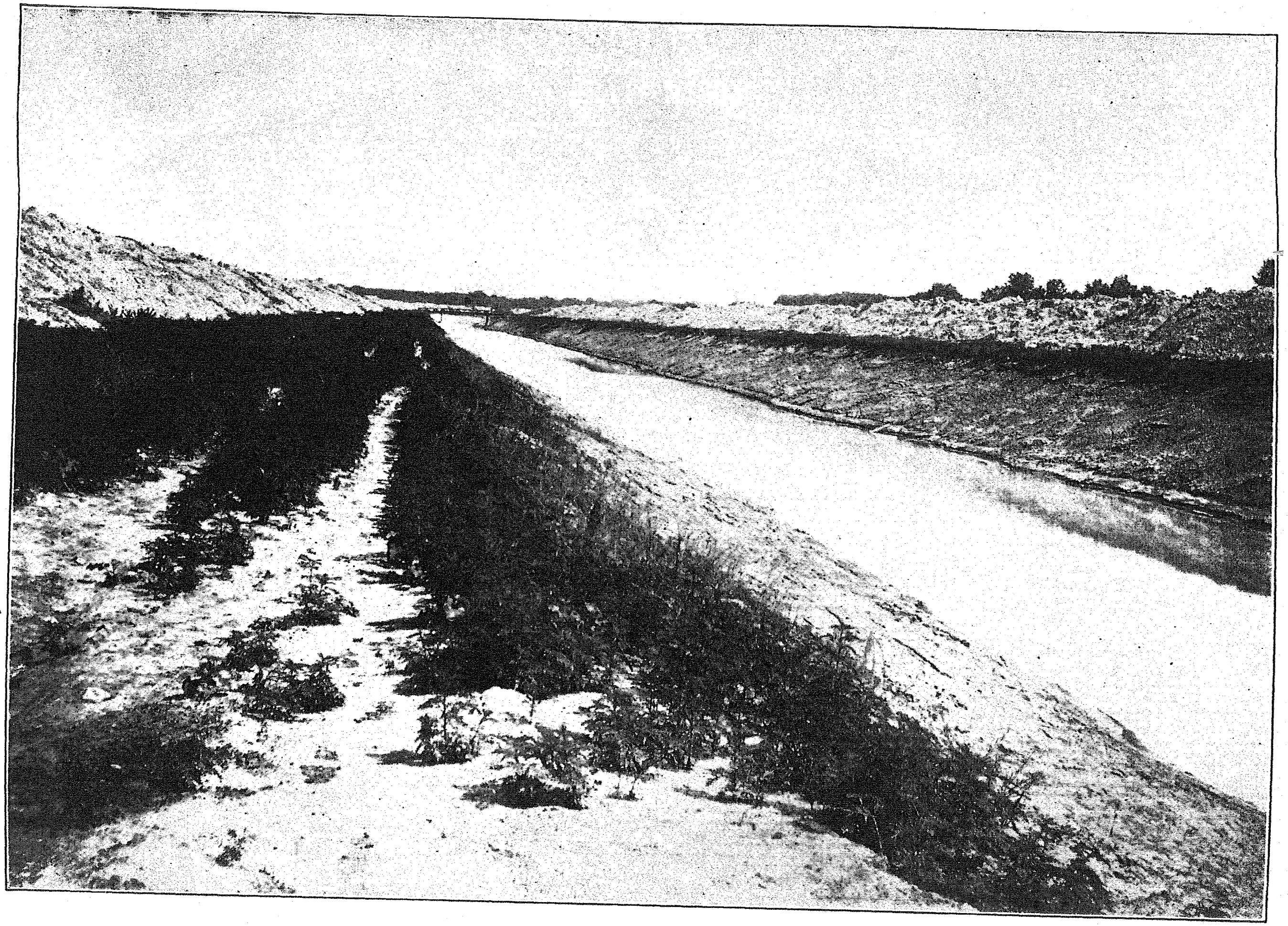

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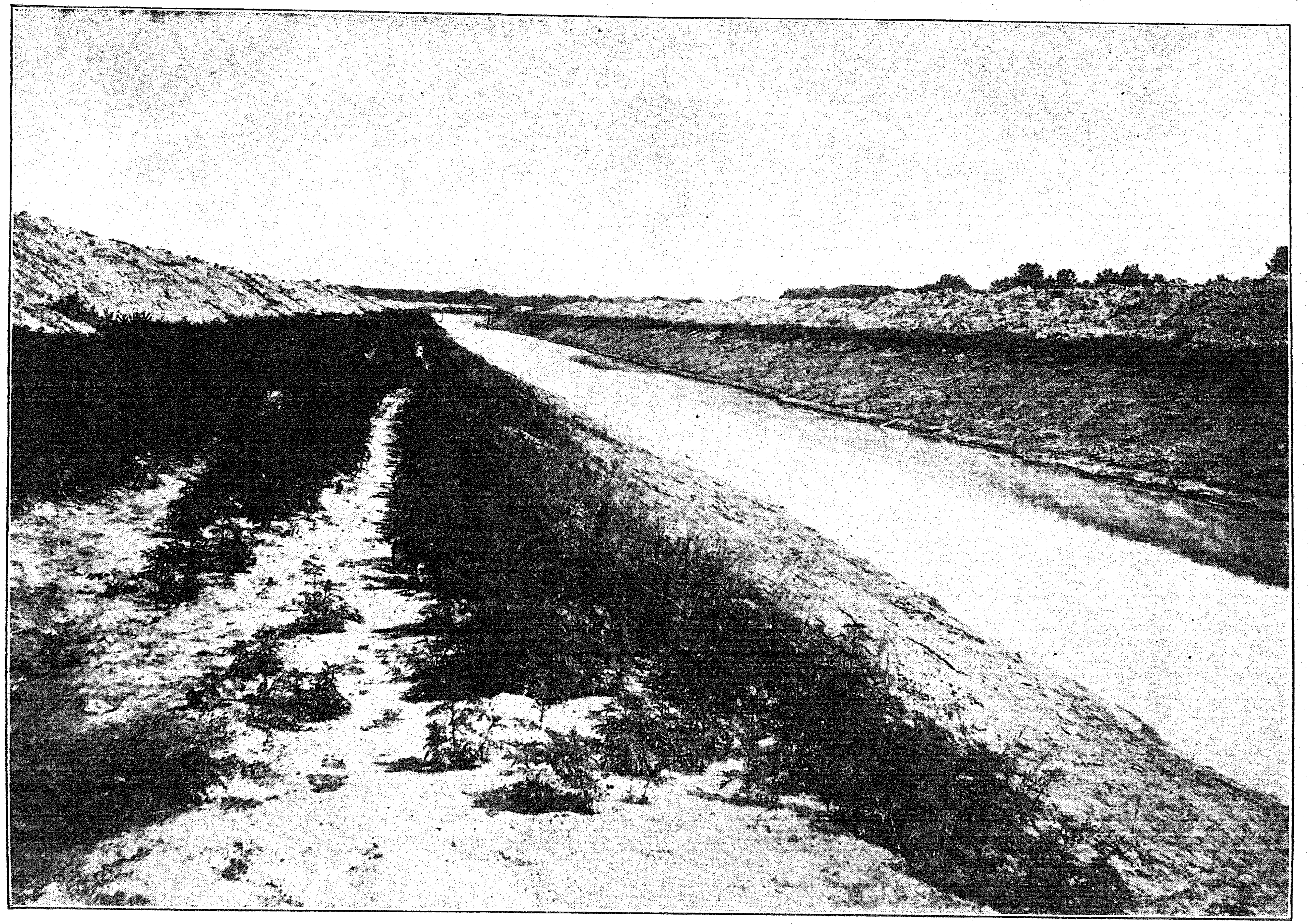

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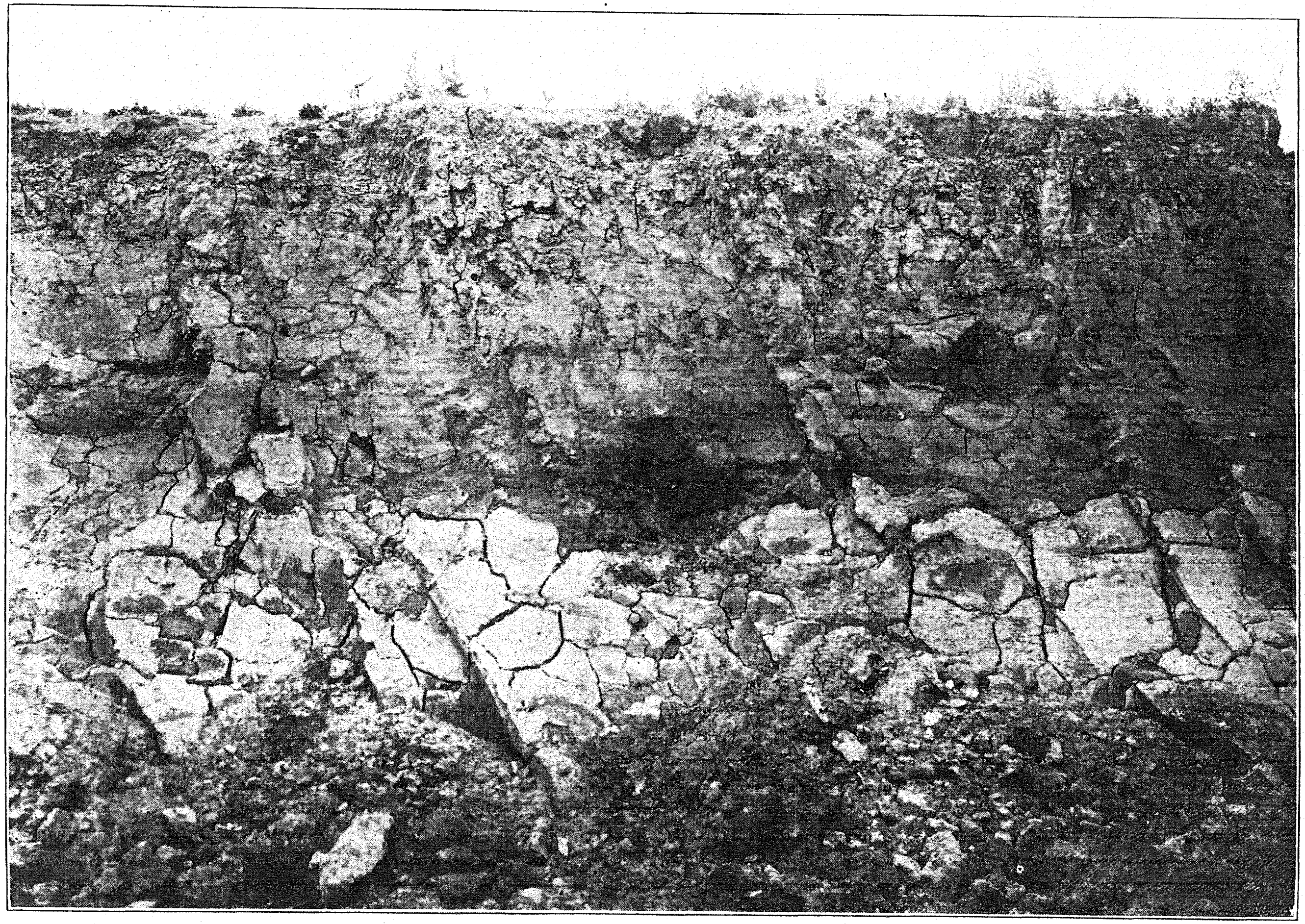
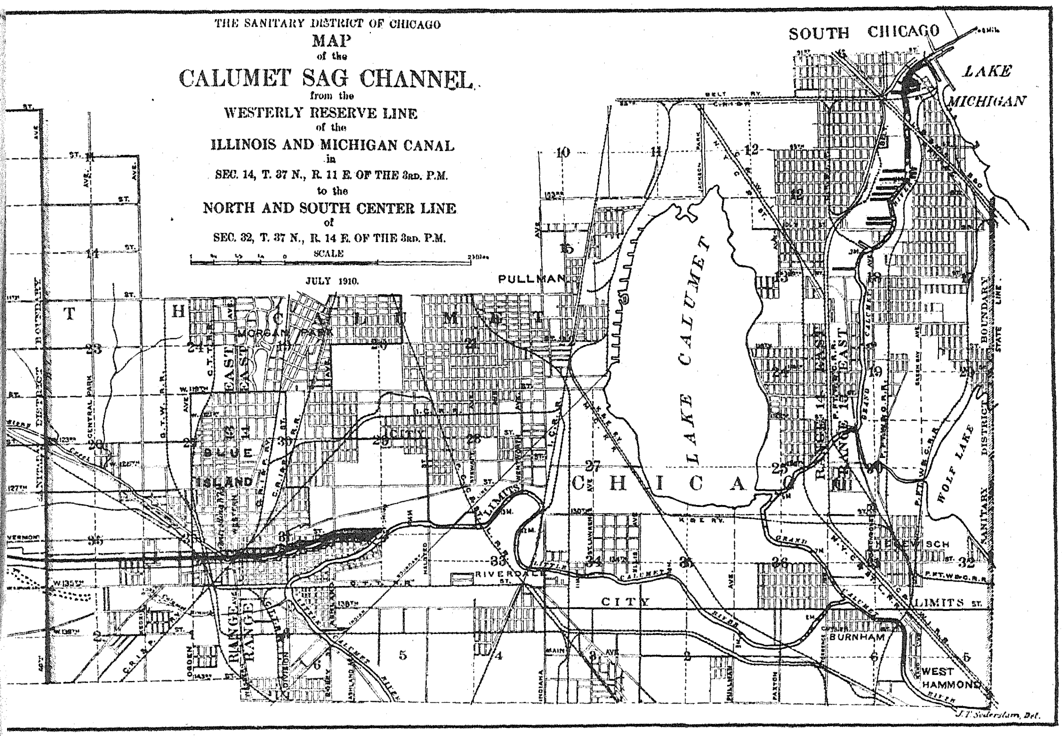
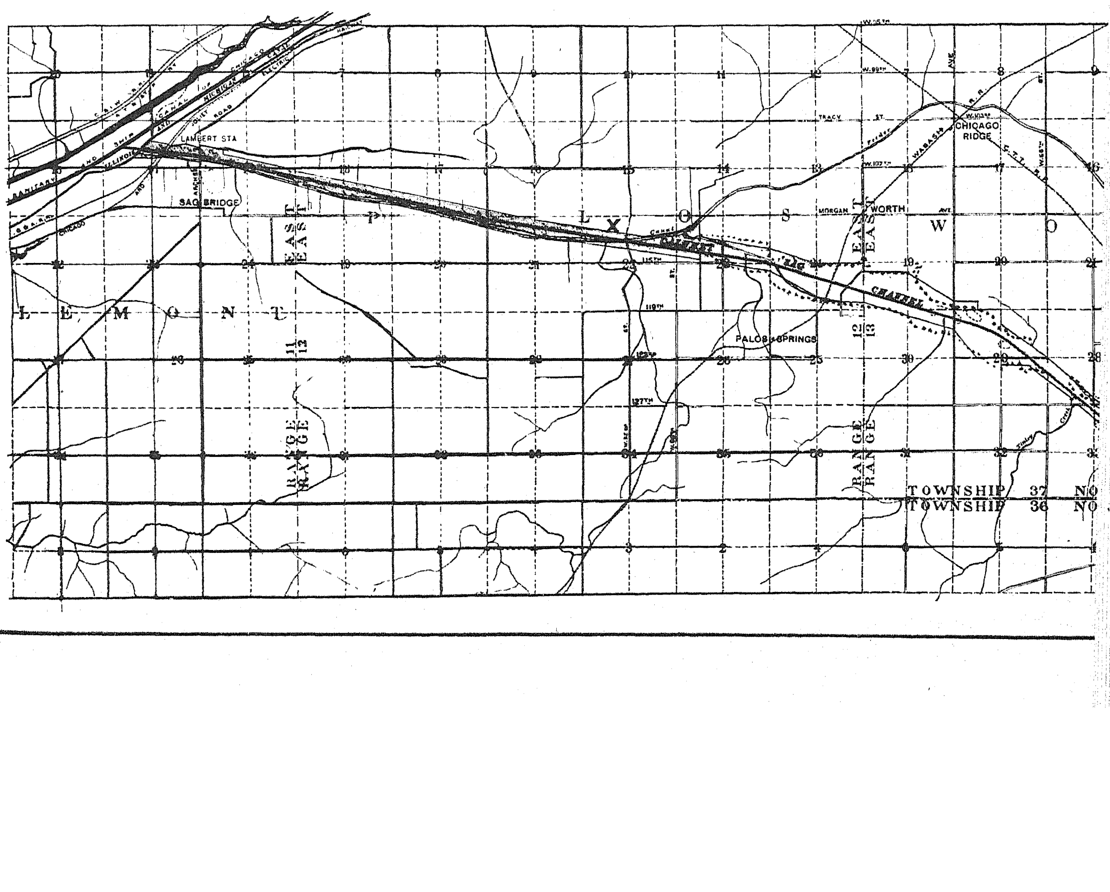



THE SANITARY DISTRICT OF CHICAGO
MAP
of the
CALUMET SAG CHANNEL
from the
WESTERLY RESERVE LINE
of the
ILLINOIS AND MICHIGAN CANAL
in
SEC. 14, T. 37 N., R. 11 E. OF THE 3RD. P.M.
to the
NORTH AND SOUTH CENTER LINE
of
SEC. 32, T. 37 N., R. 14 E. OF THE 3RD. P.M.
SCALE
JULY 1910.
SOUTH CHICAGO
LAKE MICHIGAN
LAKE CALUMET
WOLF LAKE
PULLMAN
MORGAN PARK
BLUE ISLAND
RIVERDALE
BURNHAM
WEST HAMMOND
CHICAGO
CITY
LIMITS ST.
SANITARY DISTRICT BOUNDARY
STATE LINE
J.T. Soderstam, Del.

PLAT



LAMBERT STA
SAG BRIDGE
EAST
EAST
RANGE
RANGE
11
13
L E M O N T
PALOS SPRINGS
WORTH
CHICAGO RIDGE
TRACY ST.
MORGAN
AVE.
RANGE
RANGE
EAST
EAST
12
13
TOWNSHIP 37 NO
TOWNSHIP 36 NO

PLATE XXVI

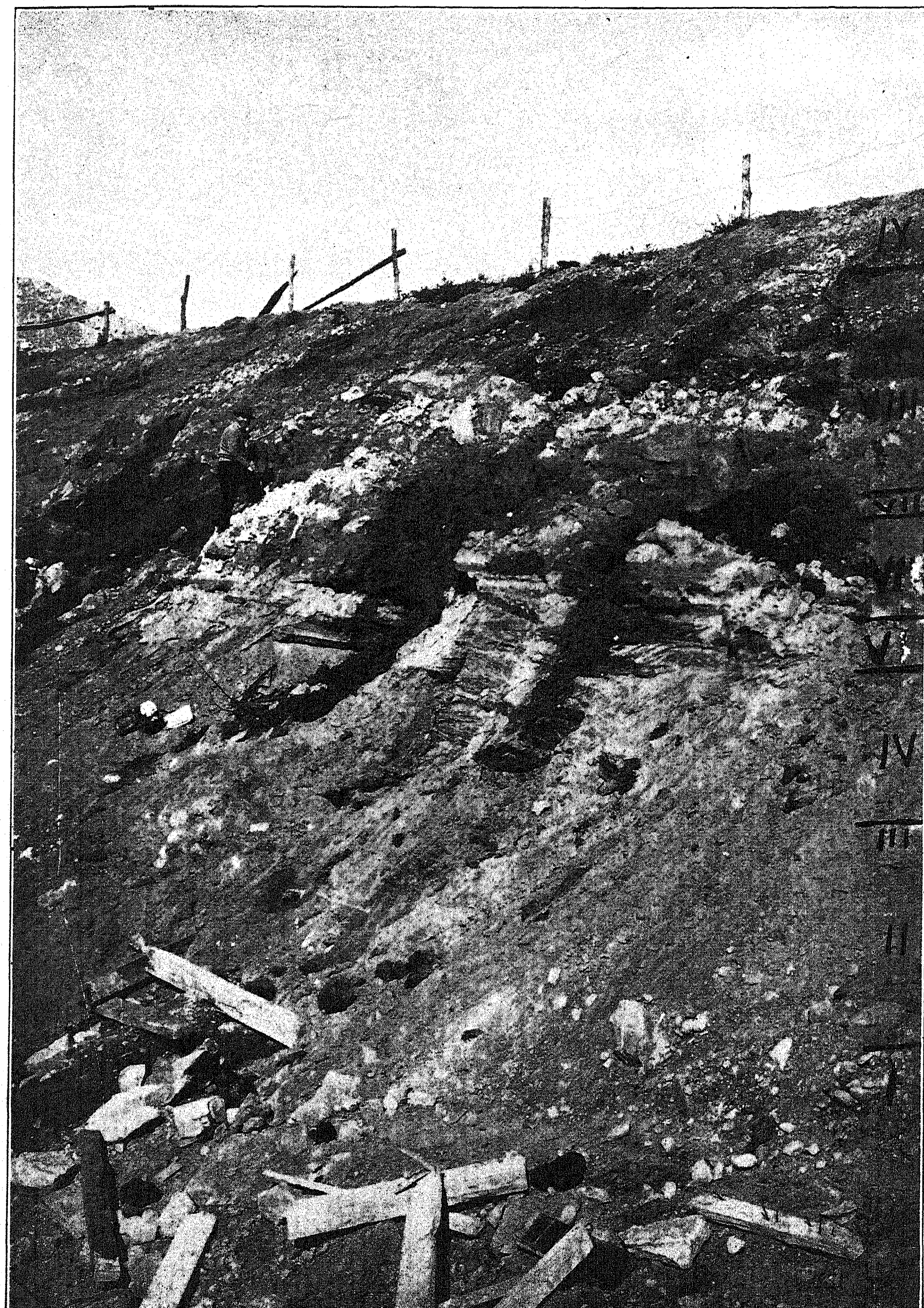


PLATE XXVII

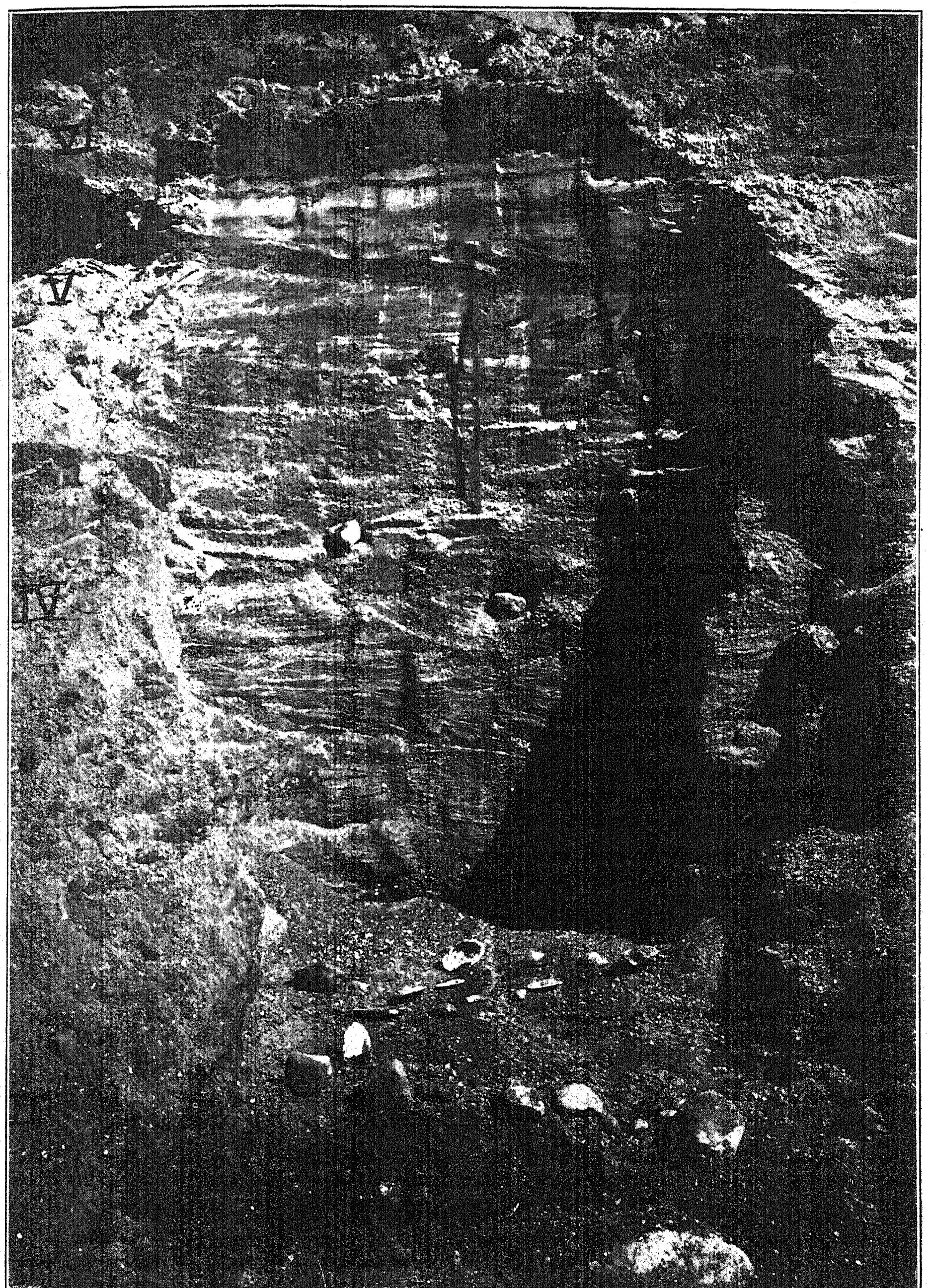


PLATE XXVIII

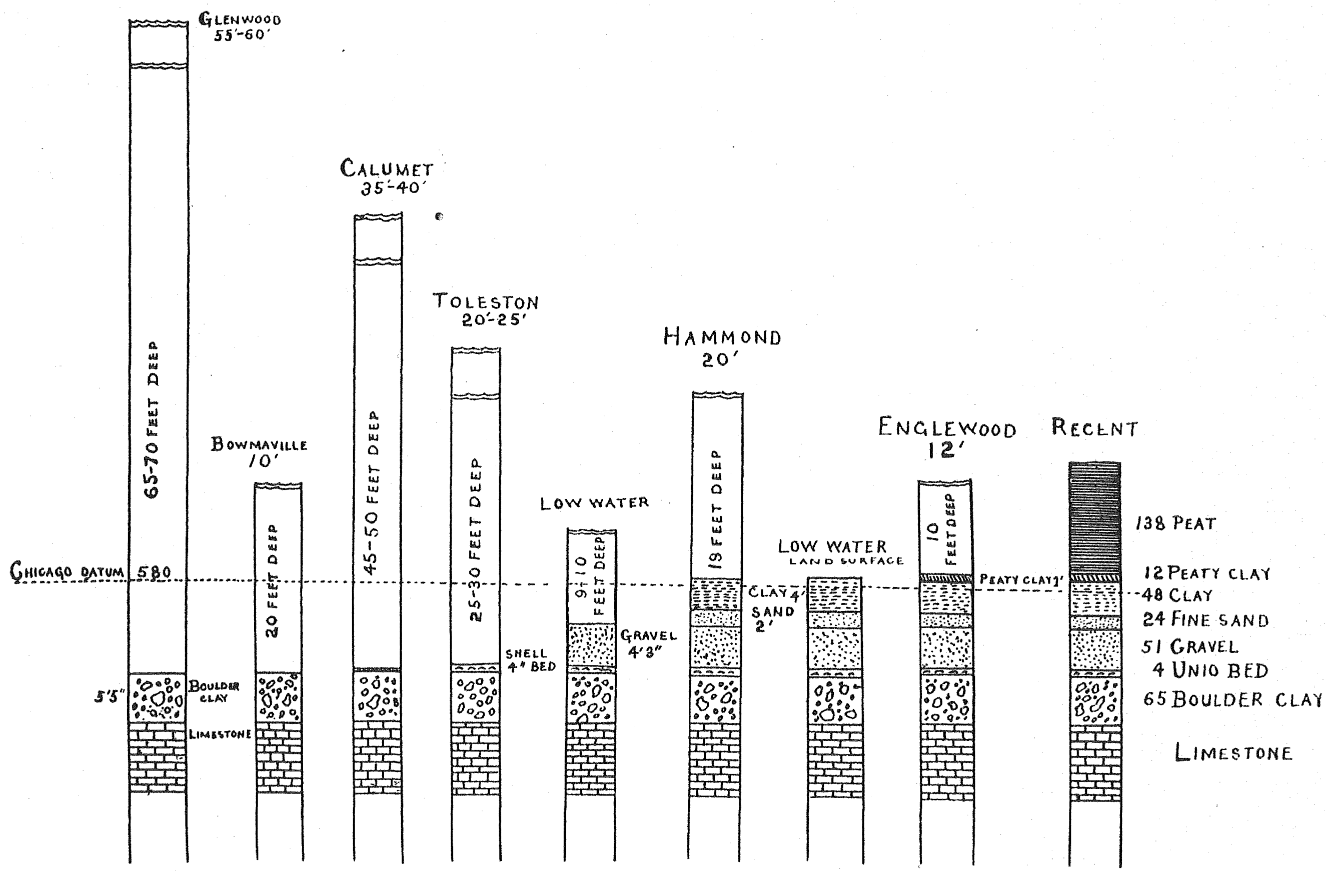


PLATE XXIX

PLATE XXX

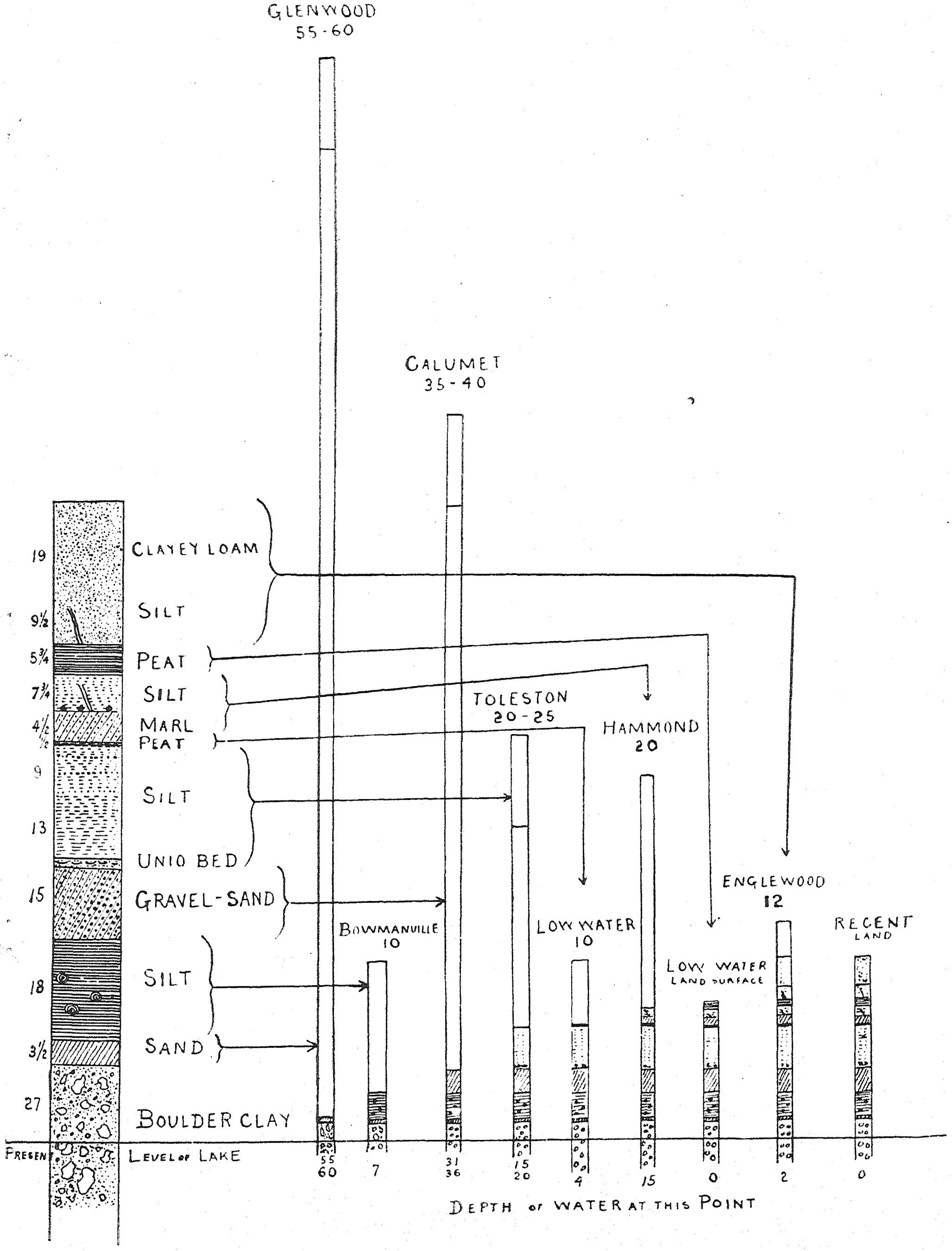

GLENWOOD
55-60
CALUMET
35-40
TOLESTON
20-25
HAMMOND
20
ENGLEWOOD
12
BOWMANVILLE
10
LOW WATER
10
LOW WATER
LAND SURFACE
RECENT
LAND
19
CLAYEY LOAM
9½
SILT
5¾
PEAT
7¾
SILT
4½
MARL
½
PEAT
9
SILT
13
UNIO BED
15
GRAVEL-SAND
18
SILT
3½
SAND
27
BOULDER CLAY
PRESENT LEVEL OF LAKE
55
60
7
31
36
15
20
4
15
0
2
0
DEPTH OF WATER AT THIS POINT

PLATE XXXI

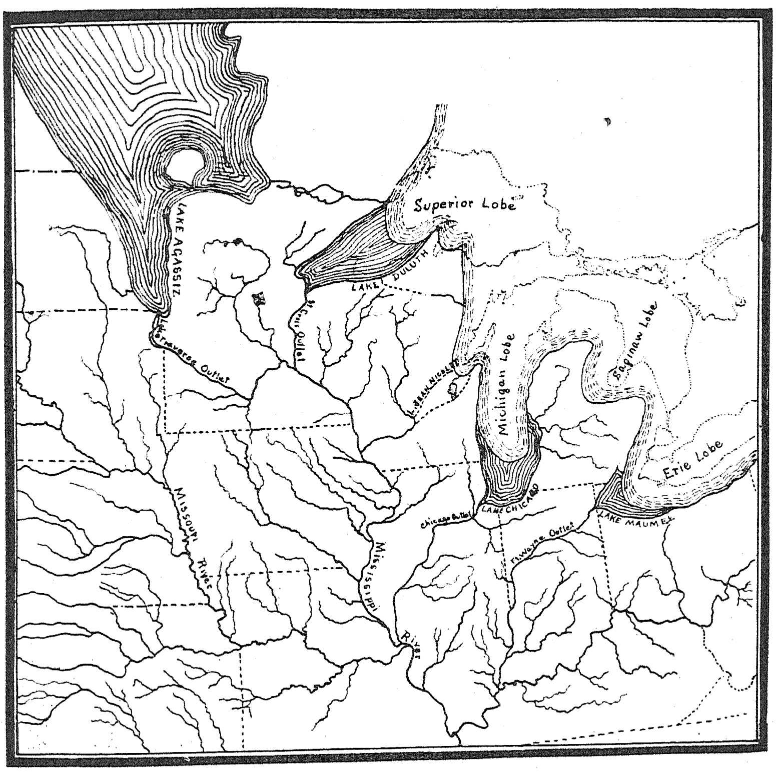

Superior Lobe
LAKE AGASSIZ
LAKE DULUTH
St. Croix Outlet
Traverse Outlet
Michigan Lobe
Saginaw Lobe
Erie Lobe
LAKE CHICAGO
Chicago Outlet
Ft. Wayne Outlet
LAKE MAUMEE
Missouri River
Mississippi River

PLATE XXXII

GLENCOE
WINNETKA
CHICAGO RIVER
SKOKIE BAY
CHICAGO BAY
DESPLAINES RIVER
NORWOOD PARK
DESPLAINES BAY
ELMHURST
SALT CREEK
MAYWOOD
OAK PARK
LA GRANGE
FLAG CREEK
MT. FOREST ISLAND
BLUE ISLAND
LEMONT
PALOS PARK
LONG RUN
SPRING CREEK
GLENWOOD
DYER
HICKORY CREEK

PLATE XXXIII

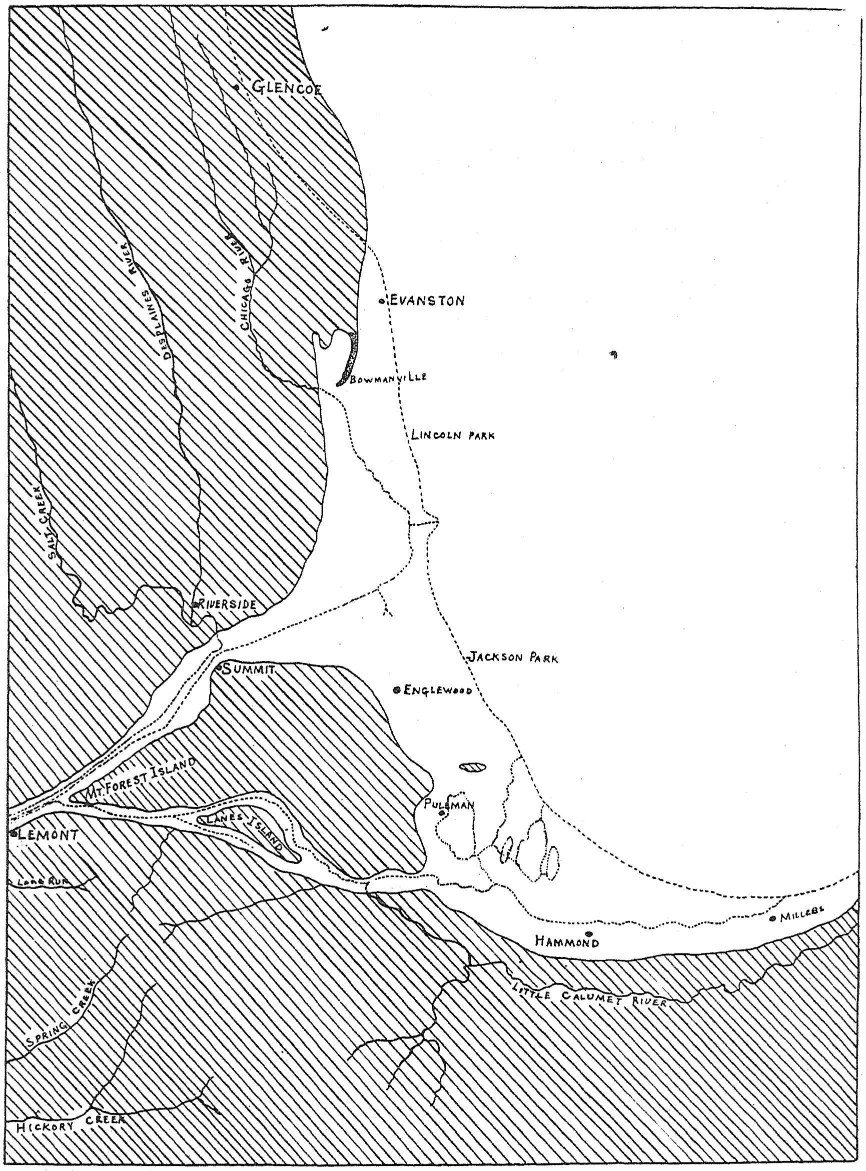


PLATE XXXIV

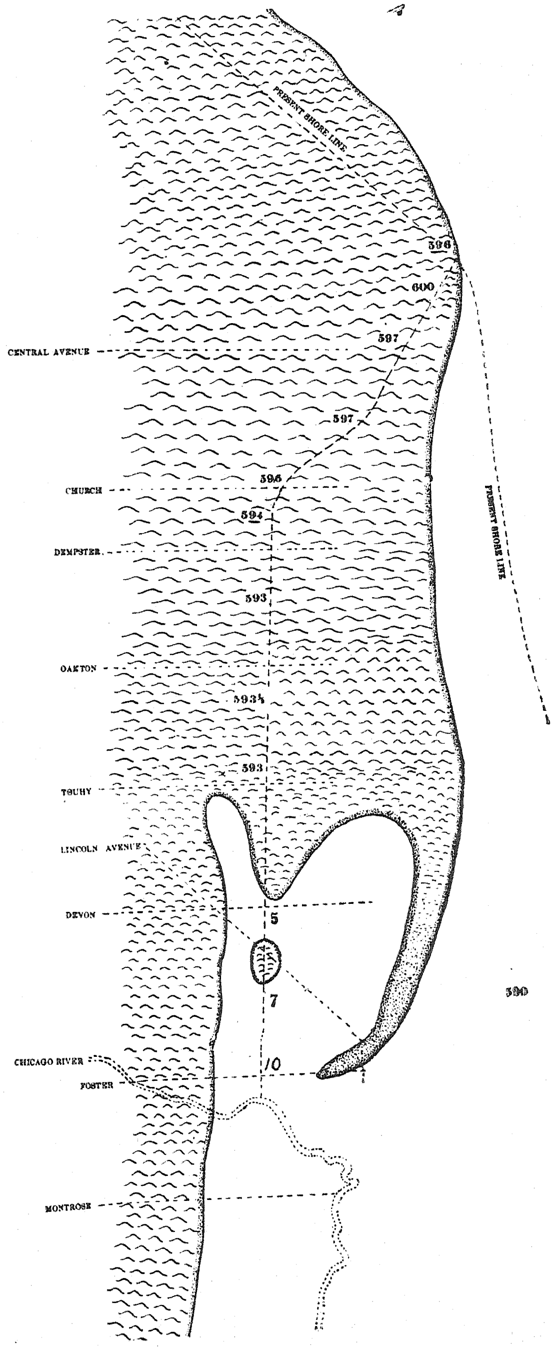

PRESENT SHORE LINE
596
600
597
CENTRAL AVENUE
597
CHURCH
595
594
DEMPSTER
593
PRESENT SHORE LINE
OAKTON
593½
593
TOUHY
LINCOLN AVENUE
DEVON
5
7
590
CHICAGO RIVER
10
FOSTER
MONTROSE

PLATE XXXV

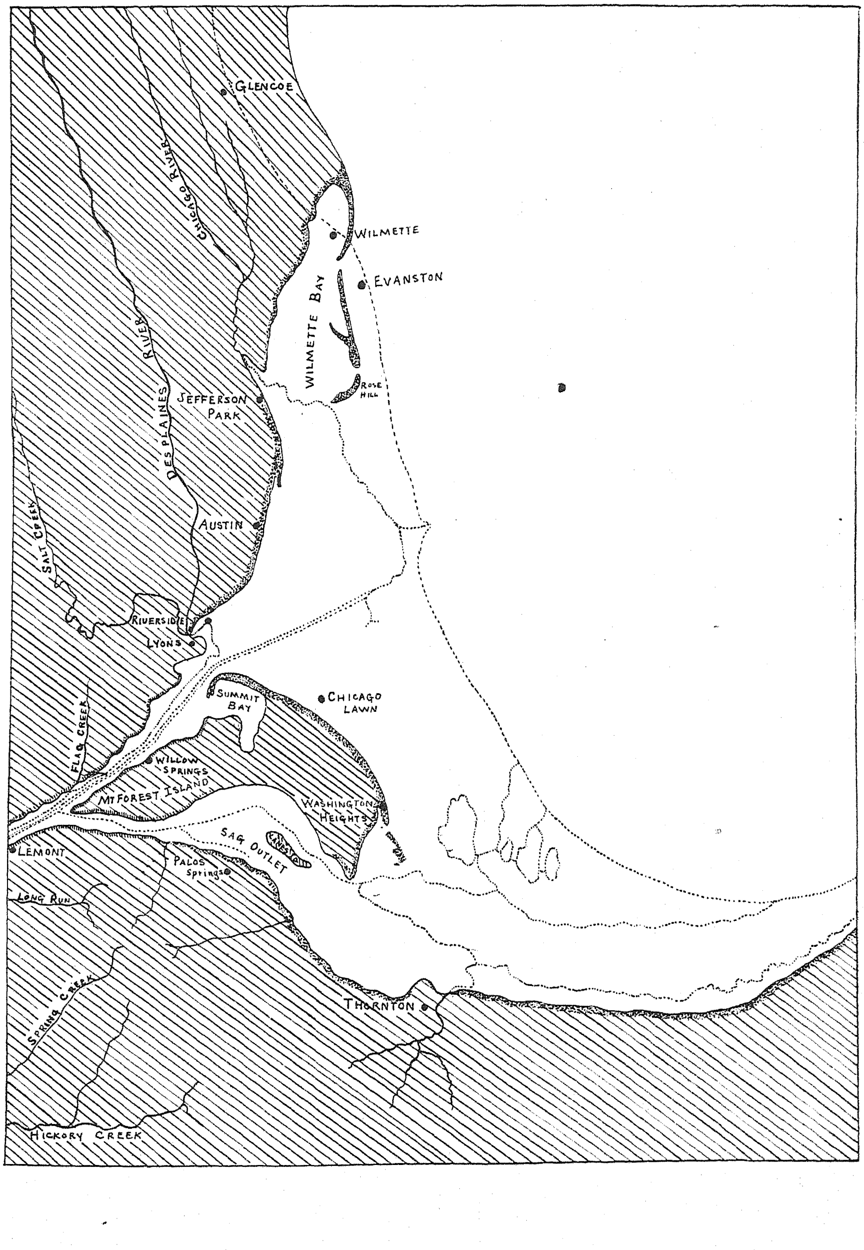

GLENCOE
CHICAGO RIVER
WILMETTE
EVANSTON
WILMETTE BAY
ROSE HILL
DESPLAINES RIVER
JEFFERSON PARK
AUSTIN
SALT CREEK
RIVERSIDE
LYONS
SUMMIT BAY
CHICAGO LAWN
FLAG CREEK
WILLOW SPRINGS
MT FOREST ISLAND
WASHINGTON HEIGHTS
SAG OUTLET
LEMONT
PALOS Springs
LONG RUN
SPRING CREEK
THORNTON
HICKORY CREEK

PLATE XXXVI

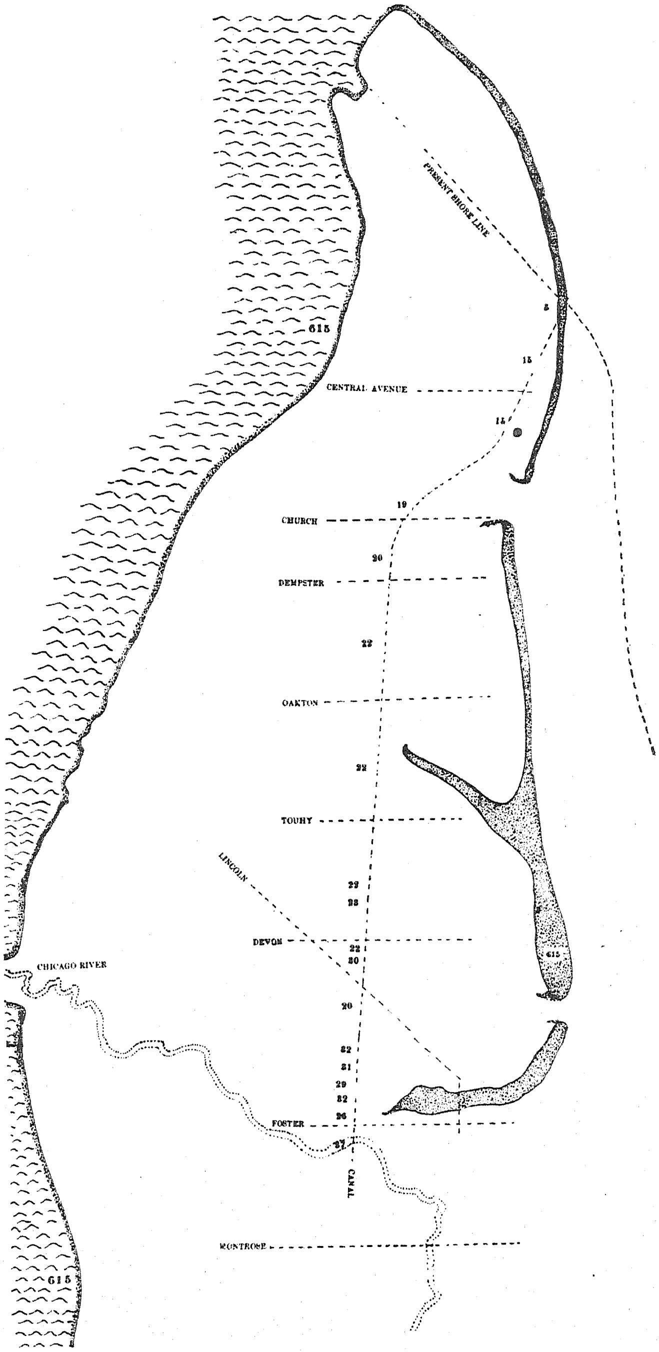
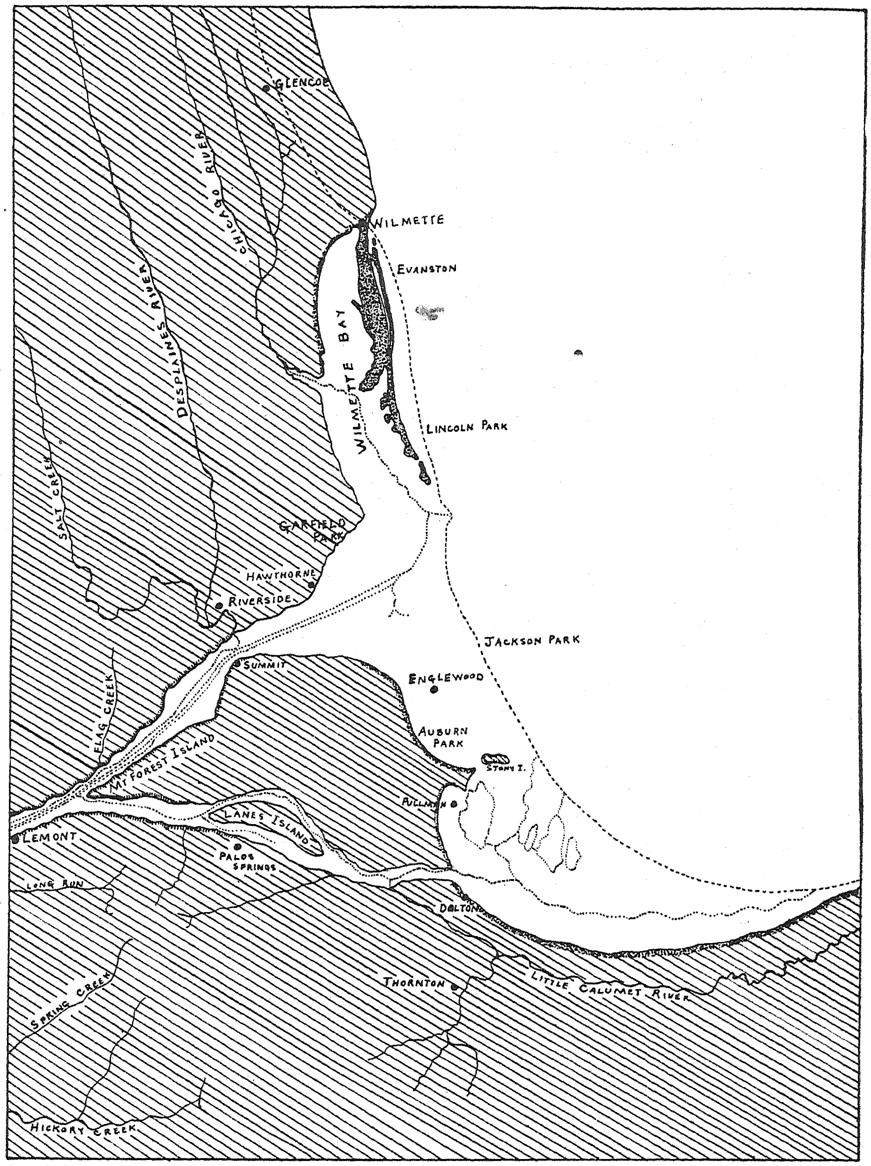

PRESENT SHORE LINE
615
CENTRAL AVENUE
CHURCH
DEMPSTER
OAKTON
TOUHY
LINCOLN
DEVON
CHICAGO RIVER
FOSTER
CANAL
MONTROSE
615

PLATE XXXVII



PLAT III


NORTH AVENUE
FULLERTON
DIVERSEY
BELMONT
MONTROSE
FOSTER
DEVON
LINCOLN
TOUHY
OAKTON
DEMPSTER
CHURCH
CENTRAL
HUMBOLDT PARK
CHICAGO RIVER
CANAL
CANAL
PRESENT SHORE LINE
600
610
605
600
LINCOLN PARK

PLATE XXXIX

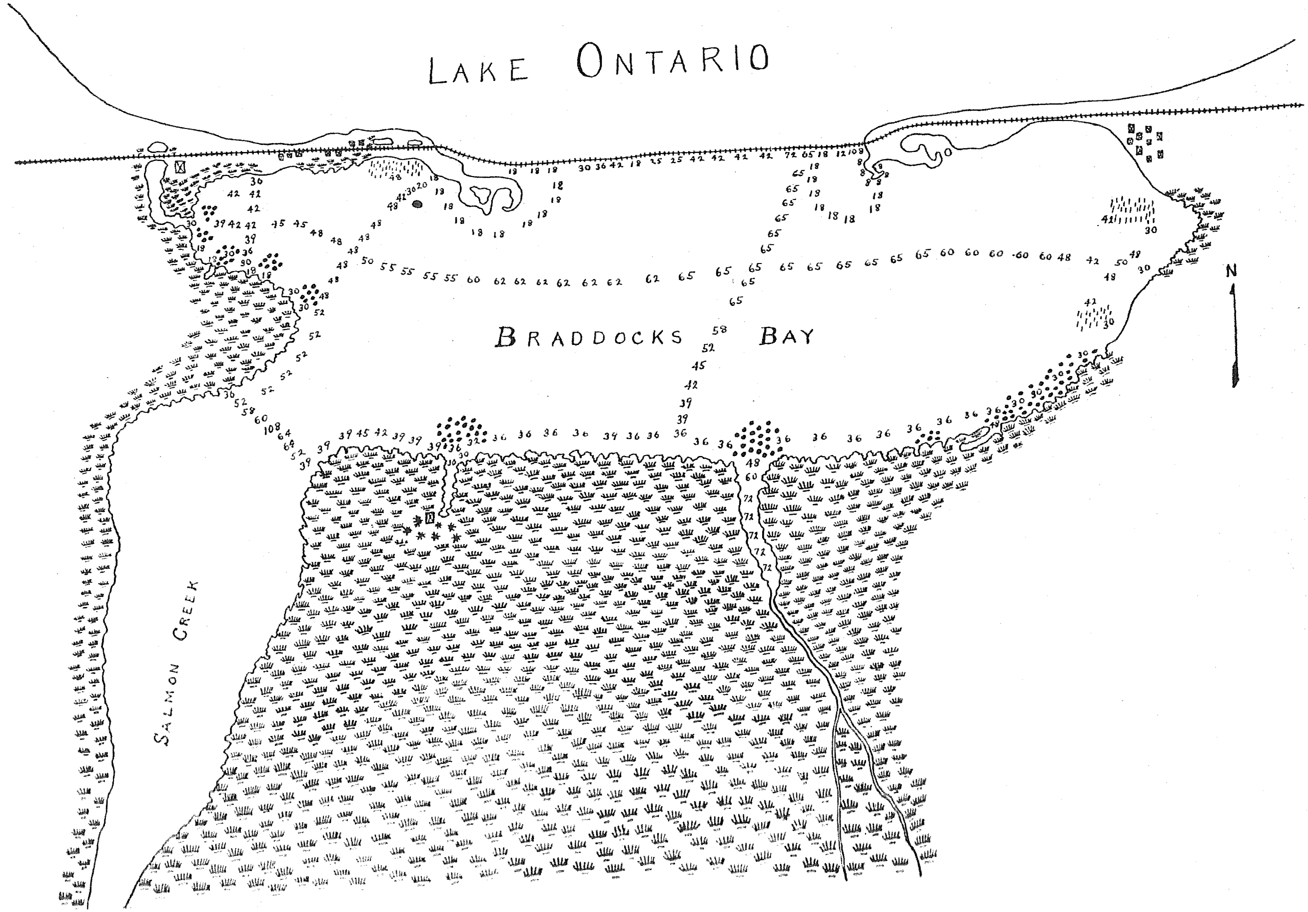


PLATE XL

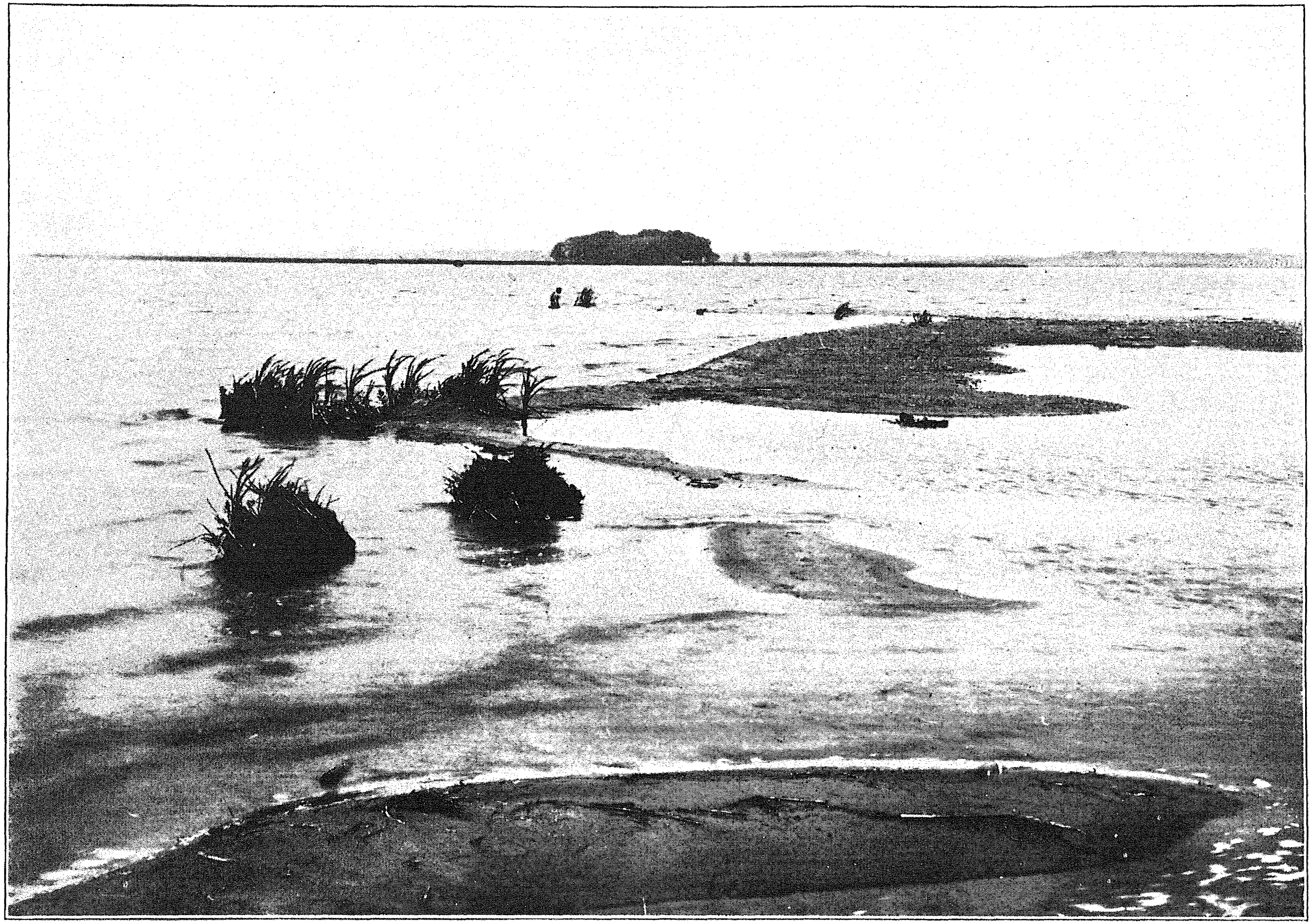


PLATE XLI

PLATE XLII

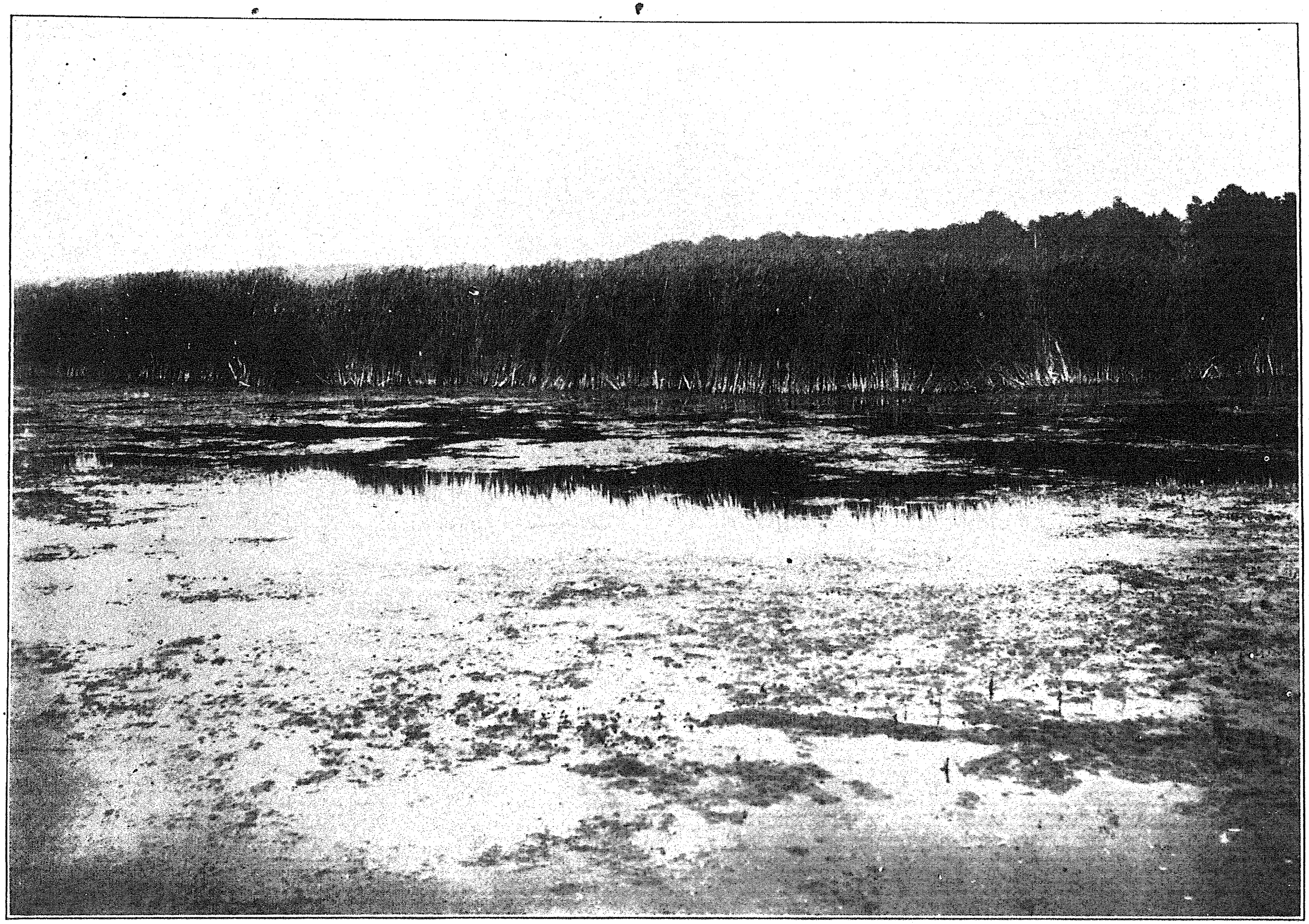
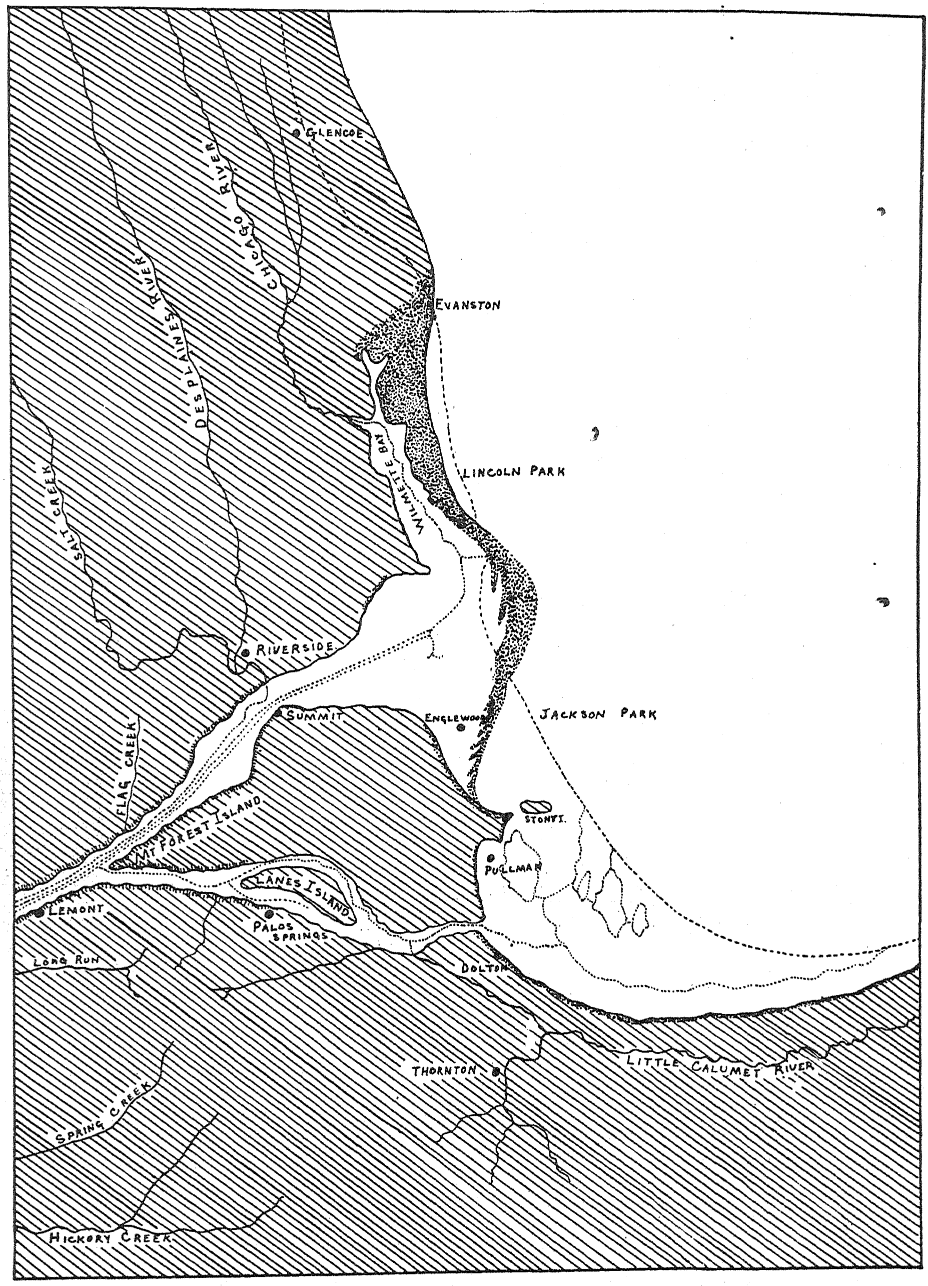


PLATE XLIII

PLATE XLIV



GLENCOE
DESPLAINES RIVER
CHICAGO RIVER
EVANSTON
SALT CREEK
WILMETTE BAY
LINCOLN PARK
RIVERSIDE
SUMMIT
ENGLEWOOD
JACKSON PARK
FLAG CREEK
MT FOREST ISLAND
STONY I.
PULLMAN
LANES ISLAND
LEMONT
PALOS SPRINGS
LONG RUN
DOLTON
THORNTON
LITTLE CALUMET RIVER
SPRING CREEK
HICKORY CREEK

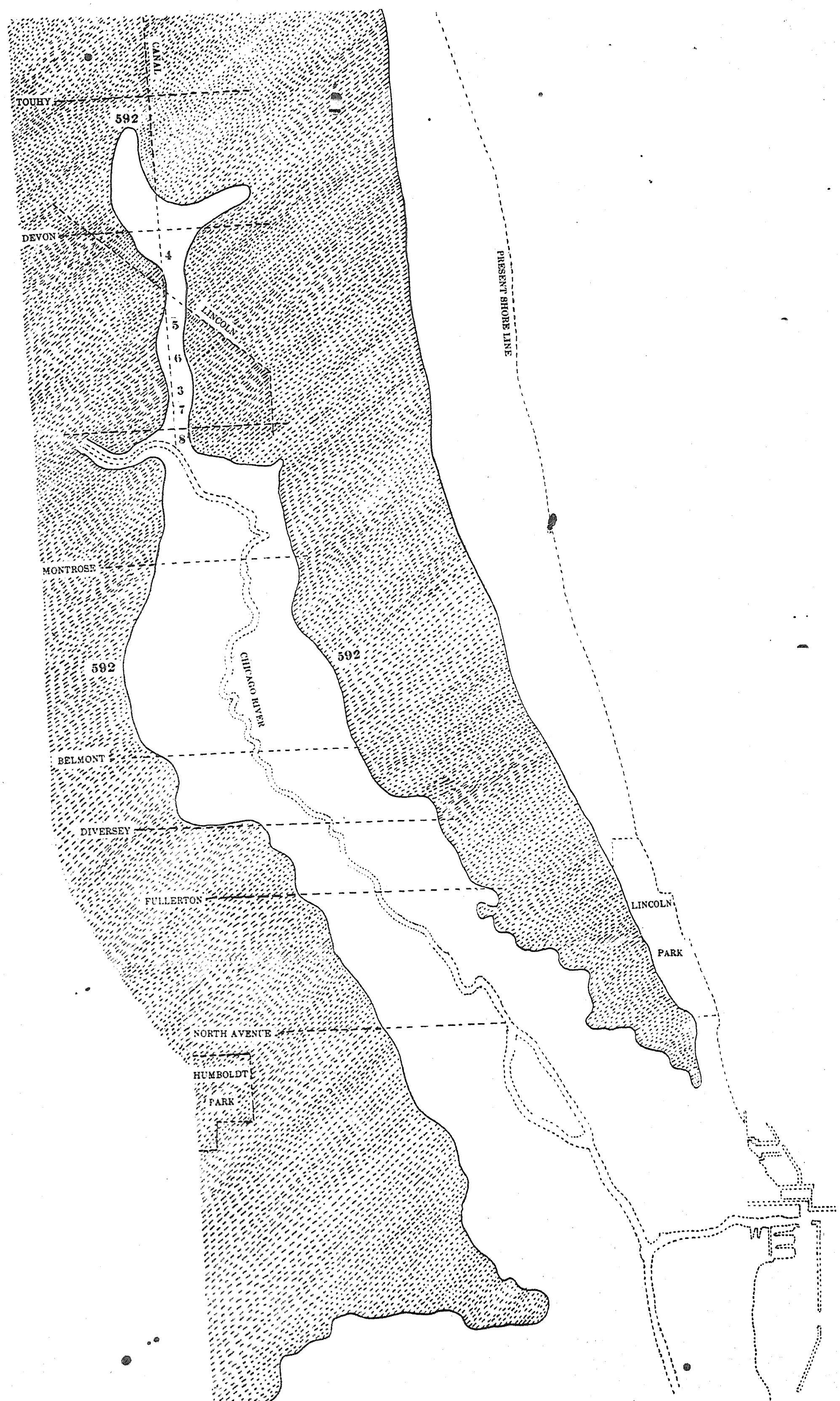
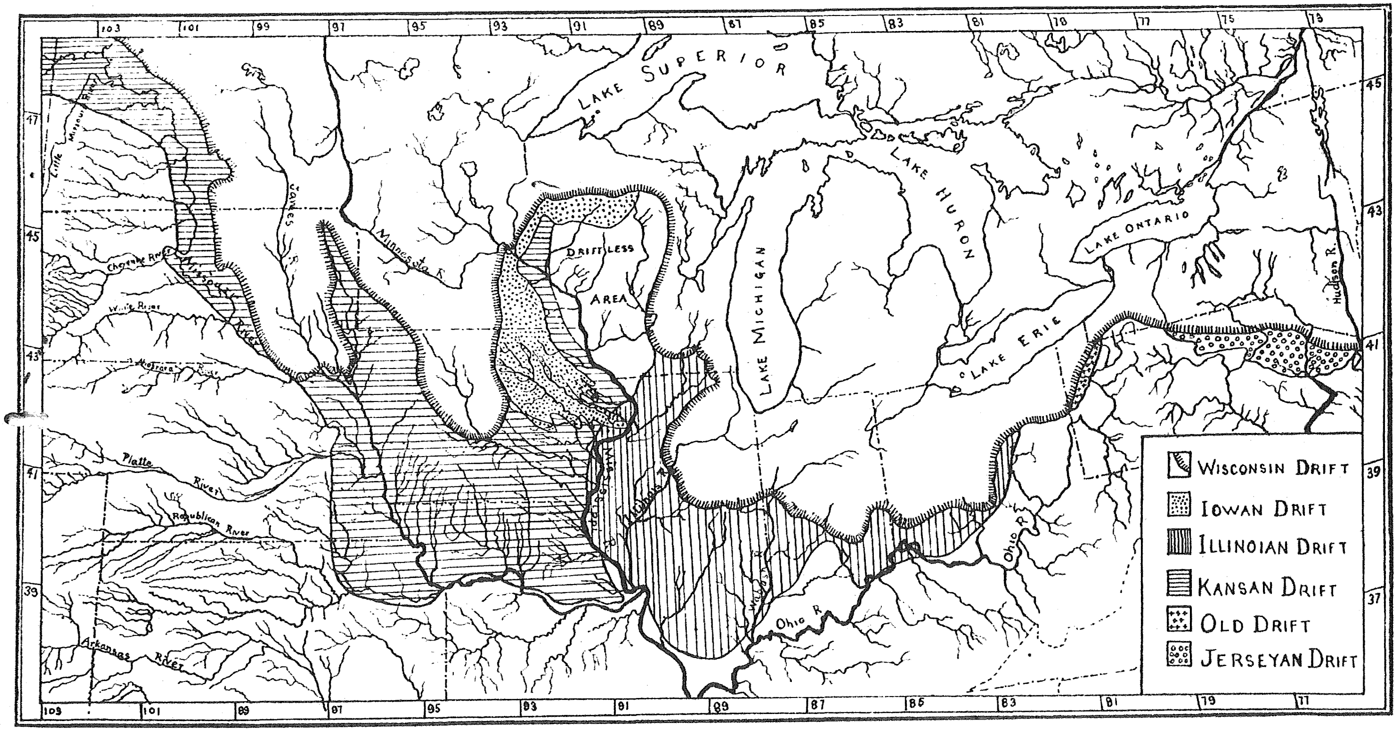

CANAL
TOUHY
592
DEVON
4
5
6
3
7
8
LINCOLN
PRESENT SHORE LINE
MONTROSE
592
592
CHICAGO RIVER
BELMONT
DIVERSEY
FULLERTON
LINCOLN
PARK
NORTH AVENUE
HUMBOLDT
PARK

PLATE XLVI



Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Driftless Area
Minnesota R.
James R.
Missouri River
Platte River
Republican River
Arkansas River
Ohio R.
Hudson R.
Wisconsin Drift
Iowan Drift
Illinoian Drift
Kansan Drift
Old Drift
Jerseyan Drift

PLATE XLVII

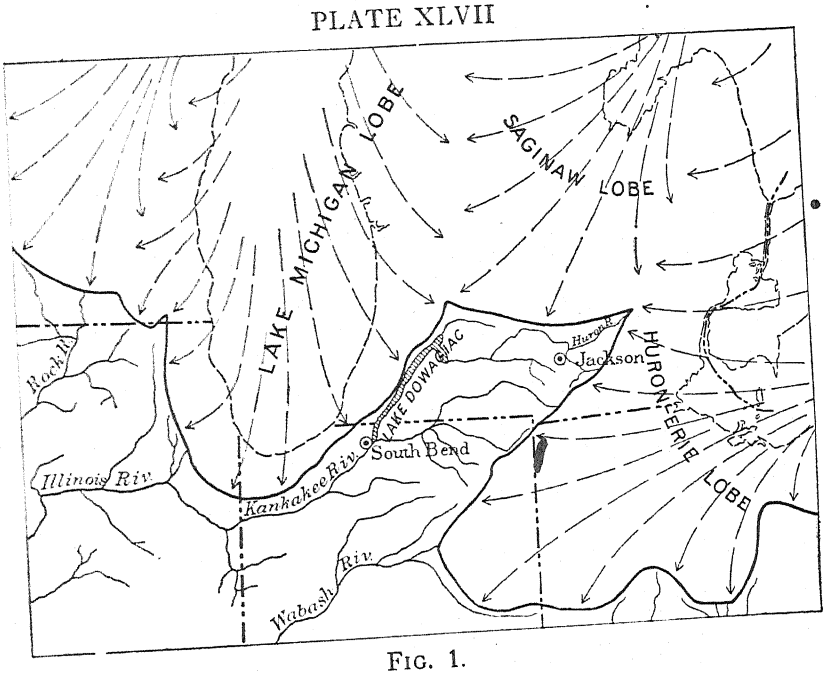


FIG. 1.

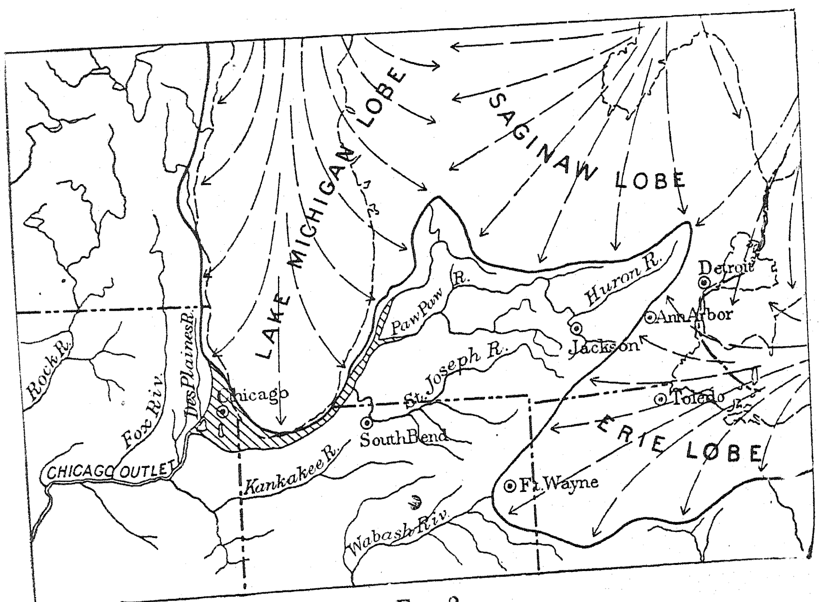


FIG 2.

PLATE XLVIII

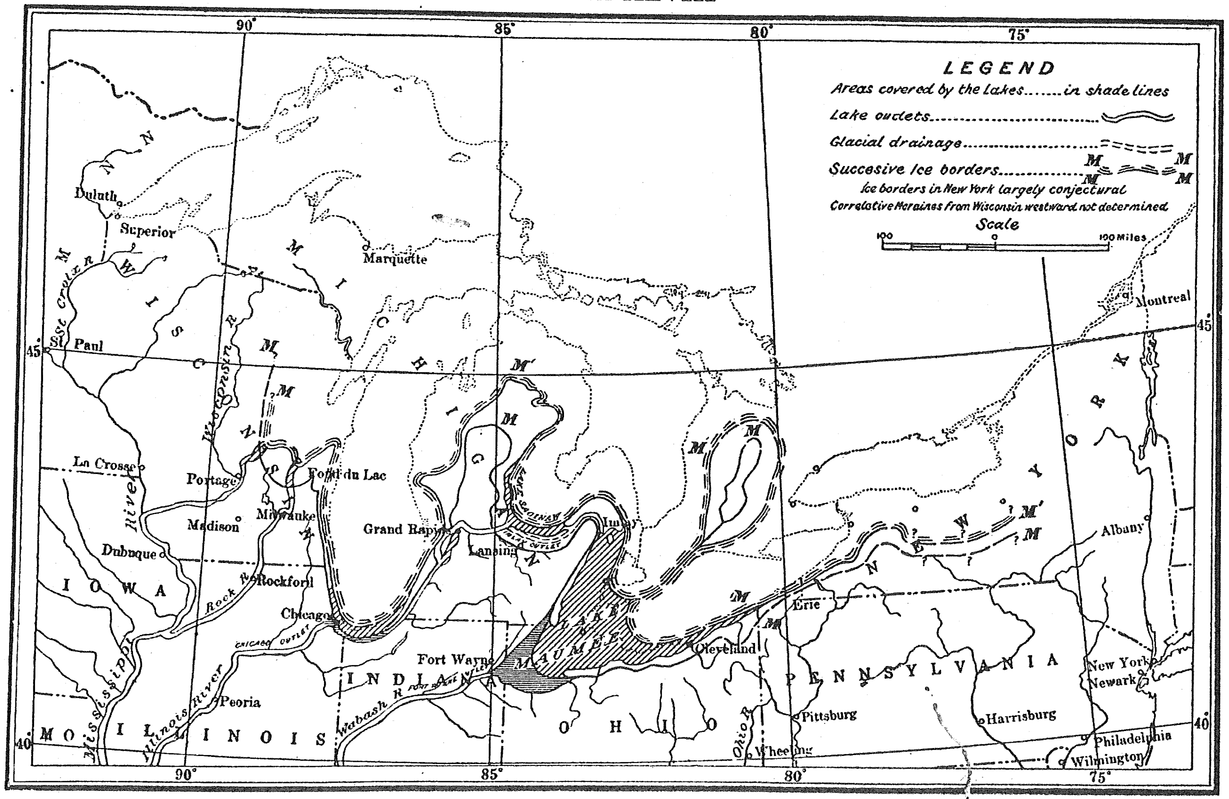
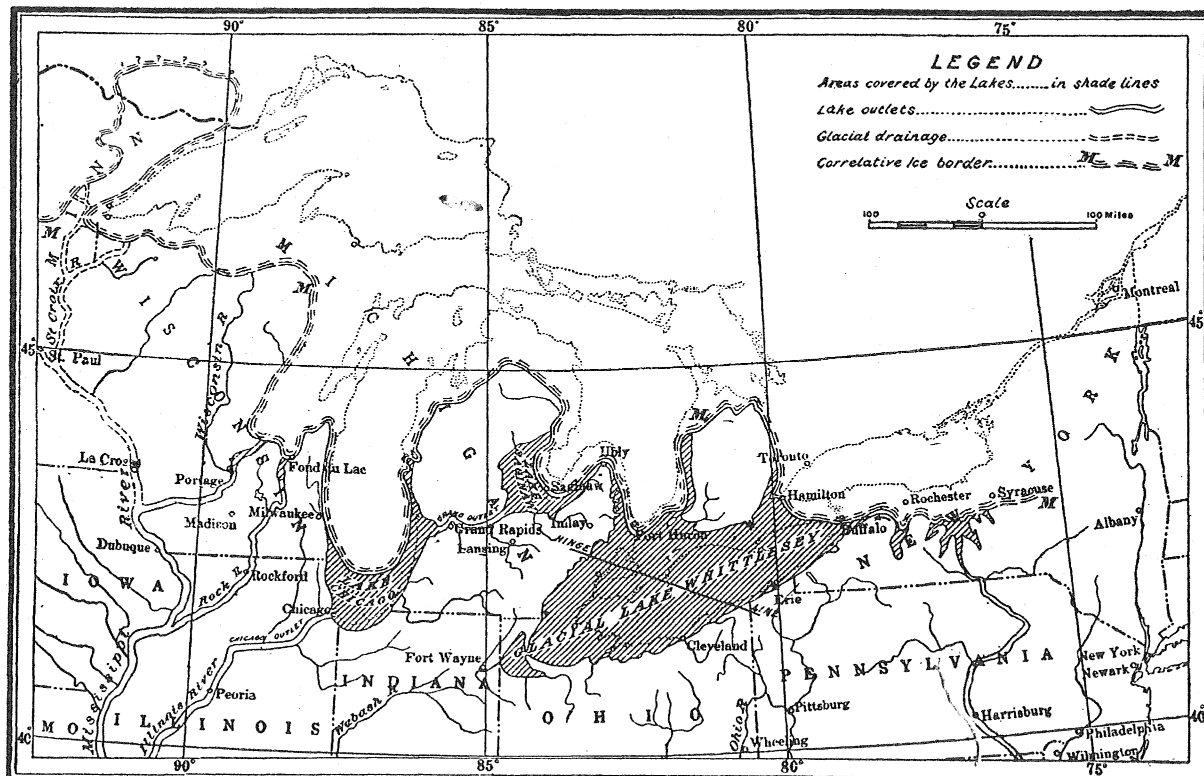
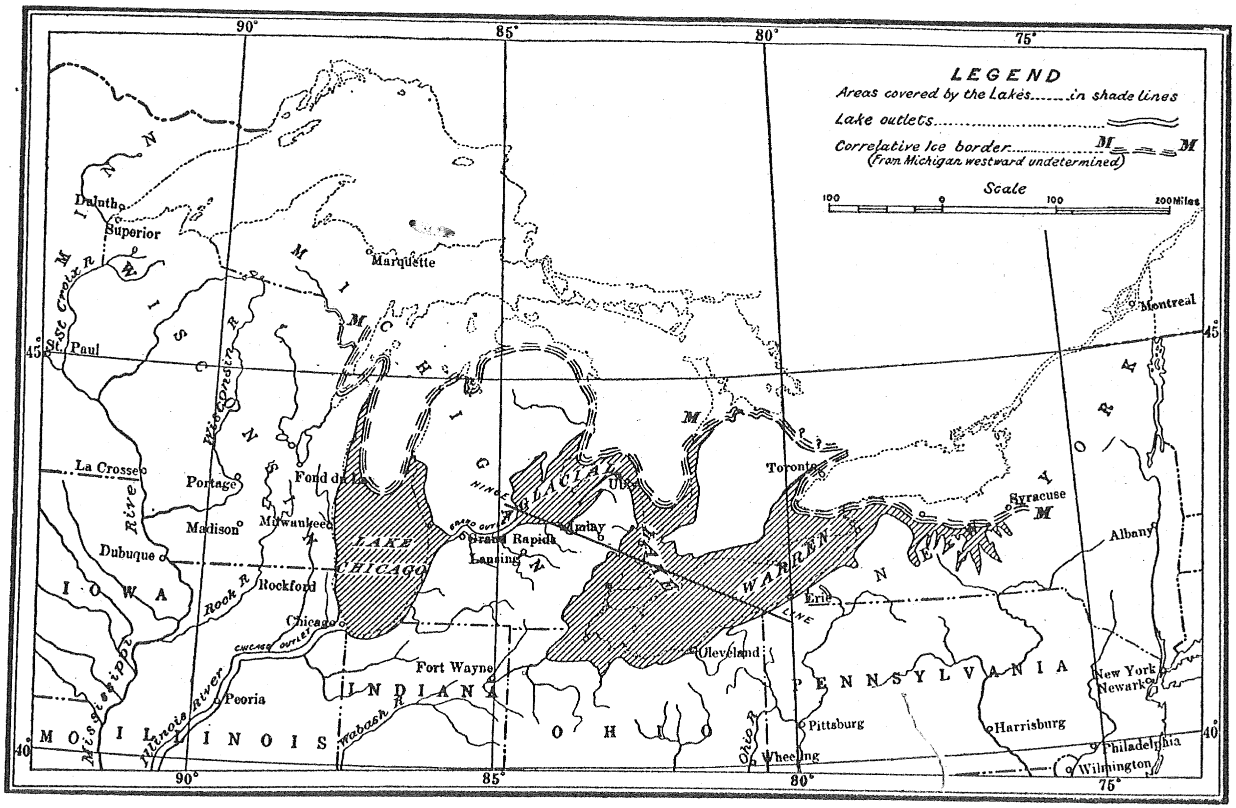


PLATE XLIX



LEGEND
Areas covered by the Lakes........in shade lines
Lake outlets
Glacial drainage
Correlative Ice border
Scale
100
100 Miles
90°
85°
80°
75°
45°
40°
St. Croix R
St. Paul
La Crosse
Mississippi River
Wisconsin R
Portage
Madison
Milwaukee
Fond du Lac
Dubuque
IOWA
Rock R
Rockford
Chicago
Chicago Outlet
Illinois River
Peoria
MO
ILLINOIS
Wabash
Fort Wayne
INDIANA
Grand Outlet
Grand Rapids
Lansing
Imlay
Saginaw
Ubly
Port Huron
HINGE LINE
GLACIAL LAKE WHITTLESEY
Cleveland
OHIO
Ohio R
Wheeling
Pittsburg
Erie
Toronto
Hamilton
Buffalo
Rochester
Syracuse
NEW YORK
Albany
Montreal
PENNSYLVANIA
Harrisburg
New York
Newark
Philadelphia
Wilmington

PLATE L



LEGEND
Areas covered by the Lakes........in shade lines
Lake outlets
Correlative Ice border
(From Michigan westward undetermined)
Scale
100
0
100
200 Miles
90°
85°
80°
75°
45°
40°
Duluth
Superior
Marquette
Montreal
St. Paul
St Croix R
Wisconsin R
La Crosse
Portage
Fond du Lac
Madison
Milwaukee
Dubuque
Rockford
Rock R
Chicago
Chicago Outlet
Peoria
Illinois River
Mississippi
Fort Wayne
Wabash R
Grand Rapids
Lansing
Grand Outlet
LAKE CHICAGO
GLACIAL
Toronto
Syracuse
Albany
Erie
Cleveland
WARREN
Pittsburg
Harrisburg
Wheeling
Ohio R
New York
Newark
Philadelphia
Wilmington
IOWA
ILLINOIS
MO
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
WISCONSIN
MICHIGAN
MINN

PLATE LI

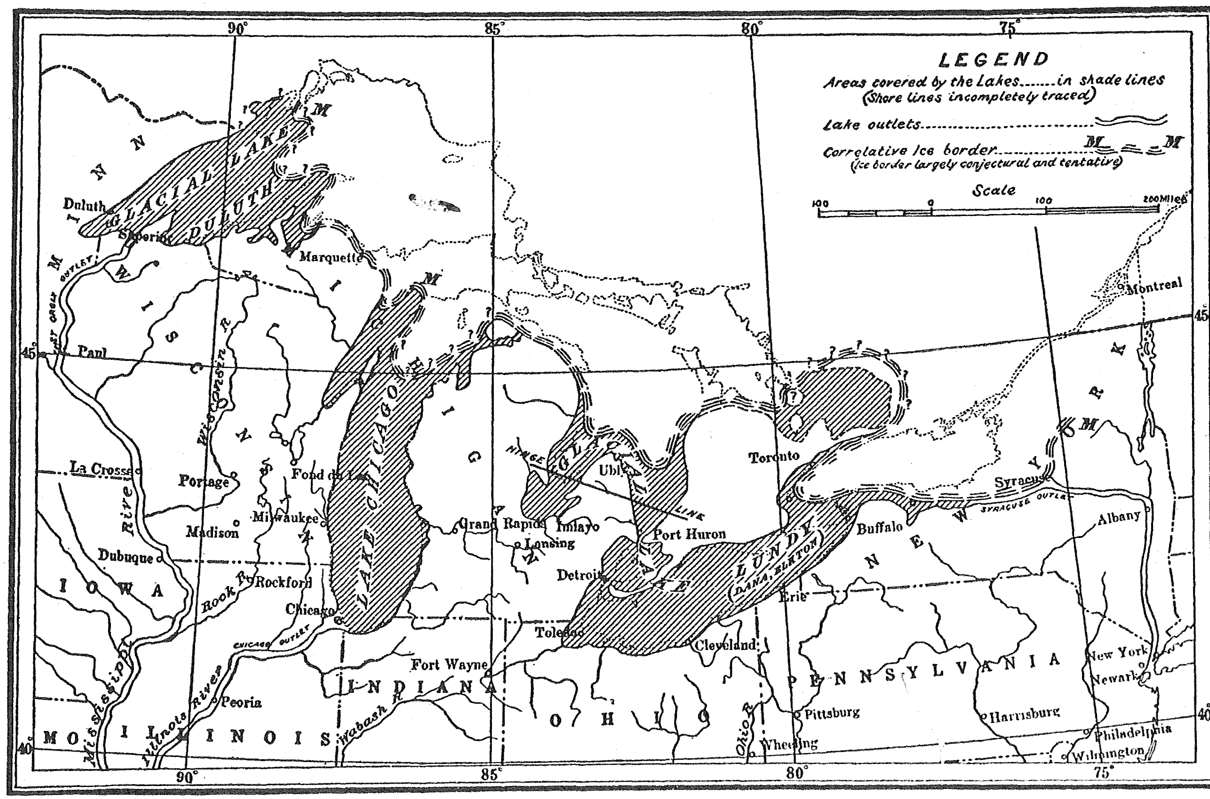

LEGEND
Areas covered by the Lakes.......in shade lines
(Shore lines incompletely traced)
Lake outlets
Correlative Ice border
(Ice border largely conjectural and tentative)
Scale
100
0
100
200 Miles
GLACIAL LAKE DULUTH
LAKE CHICAGO
LUNDY
DANA, ELKTON
HINGE LINE
SYRACUSE OUTLET
CHICAGO OUTLET
ST CROIX OUTLET
Duluth
Superior
Marquette
St. Paul
La Crosse
Portage
Madison
Dubuque
Rockford
Chicago
Fond du Lac
Milwaukee
Peoria
Fort Wayne
Toledo
Grand Rapids
Imlayo
Lansing
Port Huron
Ubly
Detroit
Cleveland
Erie
Buffalo
Toronto
Syracuse
Albany
Montreal
New York
Newark
Harrisburg
Pittsburg
Wheeling
Philadelphia
Wilmington
MINN
WISCONSIN
MICHIGAN
IOWA
ILLINOIS
MO
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
Mississippi River
Illinois River
Wabash R.
Ohio R.
Rock R.
Wisconsin R.
90°
85°
80°
75°
45°
40°

PLATE LII

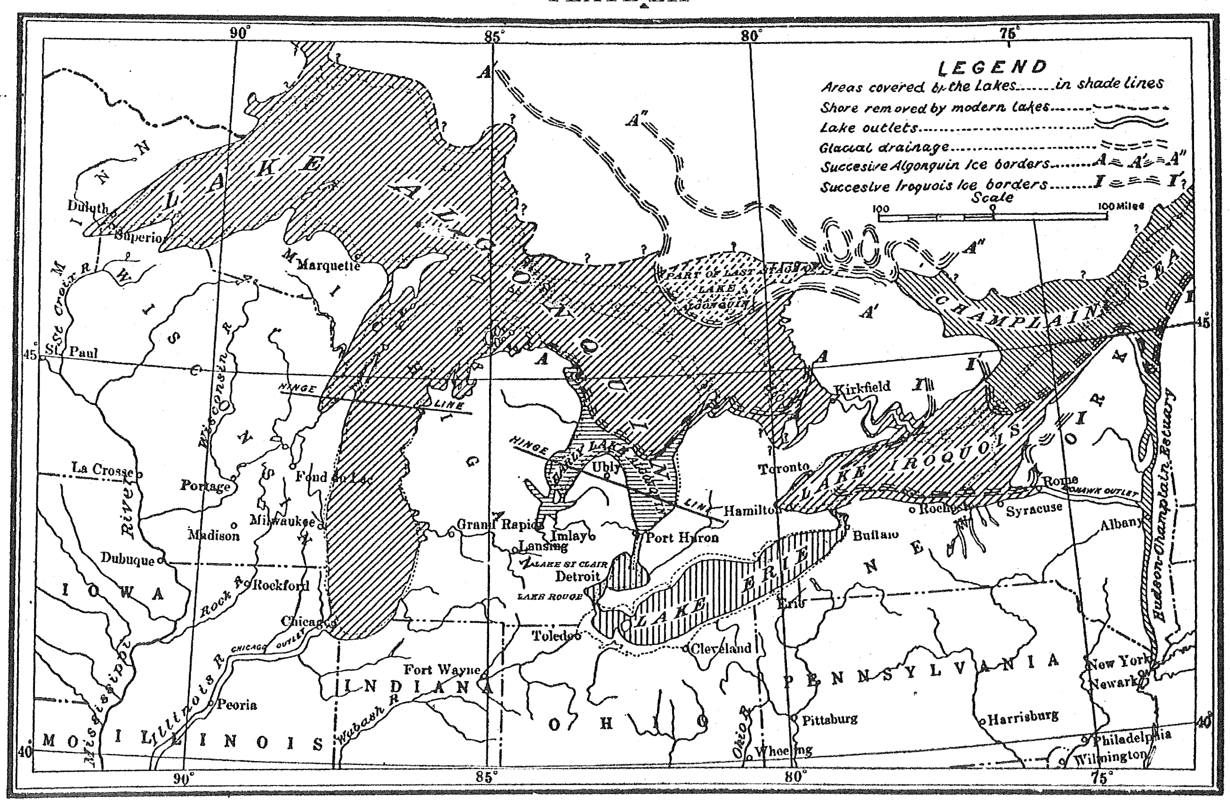
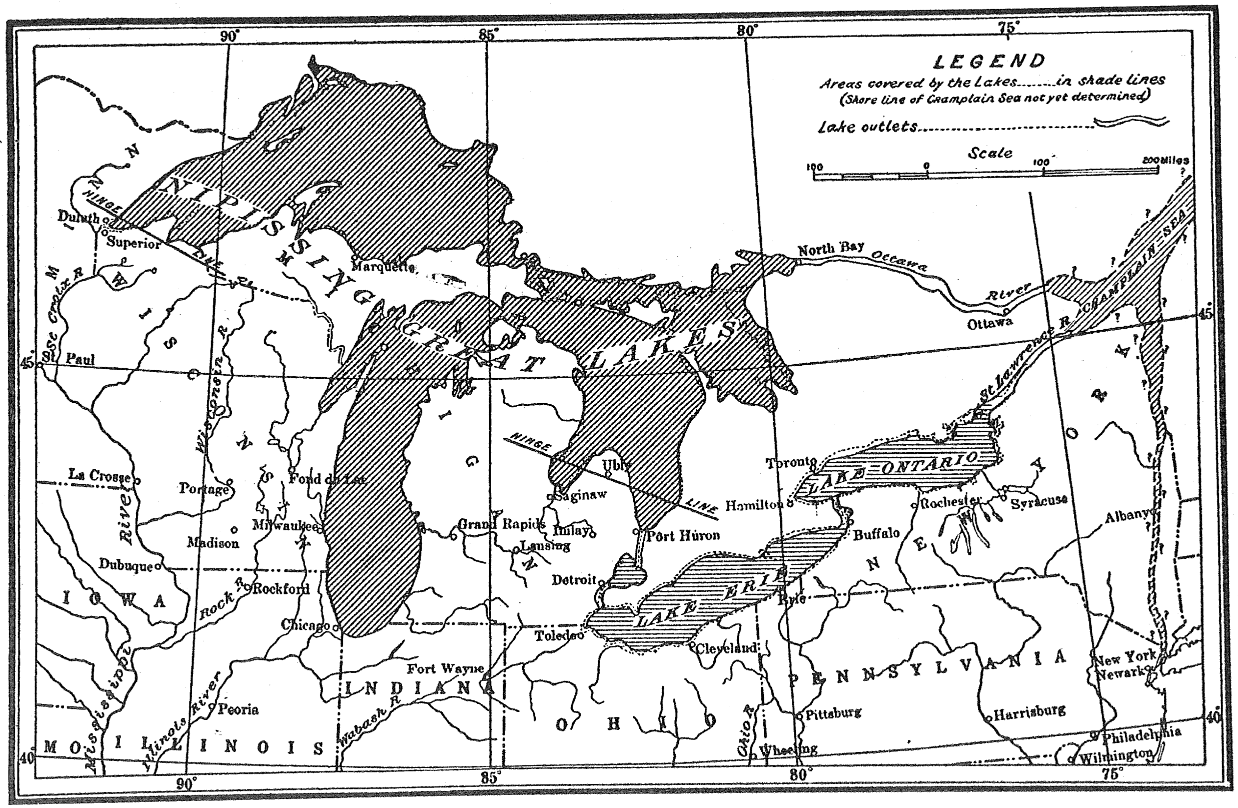
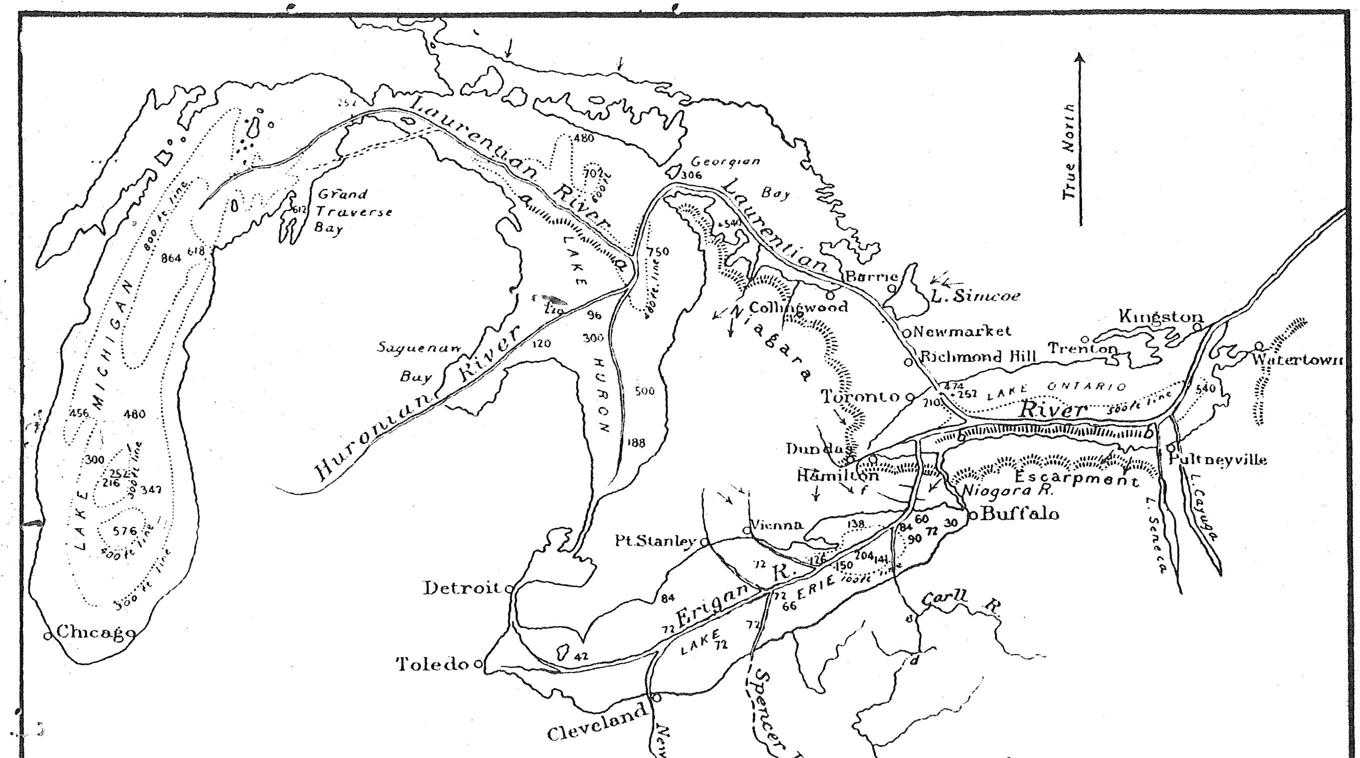

LEGEND
Areas covered by the Lakes......in shade lines
Shore removed by modern lakes
Lake outlets
Glacial drainage
Successive Algonquin Ice borders......A A' A"
Successive Iroquois Ice borders......I I'
Scale
100
100 Miles
LAKE ALGONQUIN
LAKE ERIE
LAKE IROQUOIS
CHAMPLAIN SEA
PART OF LAST STAGE OF LAKE ALGONQUIN
HINGE LINE
Hudson-Champlain Estuary
MOHAWK OUTLET
CHICAGO OUTLET
LAKE ST CLAIR
LAKE ROUGE
Duluth
Superior
Marquette
St Paul
La Crosse
Portage
Fond du Lac
Madison
Milwaukee
Dubuque
Rockford
Chicago
Peoria
Grand Rapids
Lansing
Imlay
Ubly
Port Huron
Detroit
Toledo
Fort Wayne
Cleveland
Erie
Buffalo
Hamilton
Toronto
Kirkfield
Rochester
Syracuse
Rome
Albany
New York
Newark
Philadelphia
Wilmington
Harrisburg
Pittsburg
Wheeling
IOWA
ILLINOIS
MO
INDIANA
OHIO
PENNSYLVANIA
MINN
WISCONSIN
MICHIGAN
NEW YORK
Mississippi River
Illinois R
Rock R
Wisconsin R
St Croix R
Wabash R
Ohio R
90°
85°
80°
75°
45°
40°

PLATE LIII

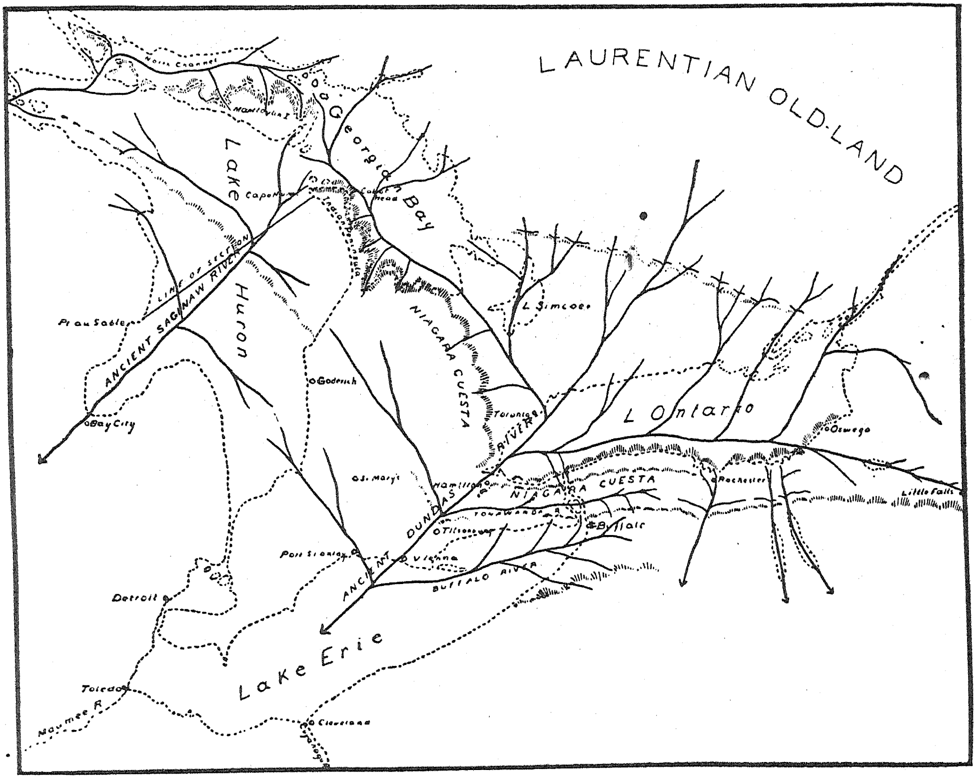


LEGEND
Areas covered by the Lakes........in shade lines
(Shore line of Champlain Sea not yet determined)
Lake outlets
Scale
100
0
100
200 Miles
90°
85°
80°
75°
45°
40°
NIPISSING
GREAT LAKES
HINGE LINE
LAKE ONTARIO
LAKE ERIE
CHAMPLAIN SEA
St. Lawrence R.
Ottawa River
North Bay
Ottawa
Duluth
Superior
Marquette
St. Paul
St. Croix R.
Wisconsin R.
La Crosse
Portage
Fond du Lac
Madison
Milwaukee
Dubuque
Rockford
Rock R.
Chicago
Peoria
Illinois River
Mississippi River
Wabash R.
Fort Wayne
Grand Rapids
Saginaw
Ubly
Imlay
Lansing
Detroit
Port Huron
Toledo
Cleveland
Toronto
Hamilton
Buffalo
Rochester
Syracuse
Albany
New York
Newark
Erie
Pittsburg
Wheeling
Ohio R.
Harrisburg
Philadelphia
Wilmington
MINN.
WISCONSIN
MICHIGAN
IOWA
MO.
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW YORK



PRECLACIAL RIVERS
OF THE
LAKE BASINS
By J.W. Spencer; additions by P. Max Foshay

PLATE LV



LAURENTIAN OLD-LAND
Georgian Bay
Lake Huron
L Ontario
Lake Erie
ANCIENT SAGINAW RIVER
LINE OF SECTION
NIAGARA CUESTA
DUNDAS RIVER
ANCIENT
BUFFALO RIVER
Tonawanda
L Simcoe
Pt au Sable
Bay City
Goderich
Toronto
Hamilton
Oswego
Rochester
Buffalo
Little Falls
Vienna
Port Stanley
Detroit
Toledo
Maumee R
Cleveland

PLATE LVI

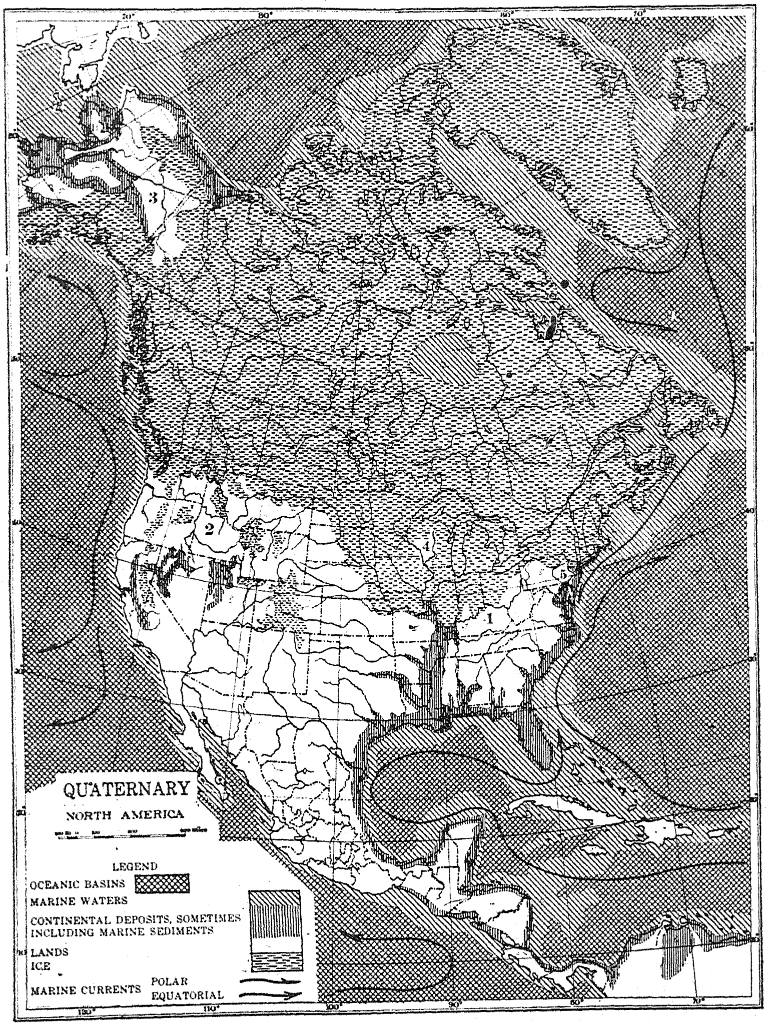

QUATERNARY
NORTH AMERICA
LEGEND
OCEANIC BASINS
MARINE WATERS
CONTINENTAL DEPOSITS, SOMETIMES INCLUDING MARINE SEDIMENTS
LANDS
ICE
MARINE CURRENTS
POLAR
EQUATORIAL

PLATE LVII

FIG. 1.

FIG. 2.